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SCIENCE & TECHNOLOGY POLICY

S&T Projects During Eighth 5-Year Plan Reviewed

92FE0359C Beijing ZHONGGUO KEJI LUNTAN [FORM ON SCIENCE AND TECHNOLOGY IN CHINA] in Chinese No 1, 18 Jan 92 pp 42-44

[Article by Zhang Wanbin [1728 8001 2430]: "China's Plan Arrangements To Attack Key S&T Problems During the Eighth 5-Year Plan"]

[Text] Editor's note: This article is based on relevant information provided by the State Science and Technology Commission Comprehensive Planning Department as well as a collection of documents that summarize plans to attack key S&T problems during the Eighth 5-Year Plan. The plan to attack key S&T problems during the Eighth 5-Year Plan is closely related to the state's 10-Year Program and Eighth 5-Year Plan. It embodies the direction of China's S&T modernization and conforms rather well to our national conditions, and it has the characteristics of seeking facts, reform, and innovation. Our recommendation of this article is for the purpose of attracting the attention of all social circles regarding attacks on key problems and to attract the participation and consciousness of S&T personnel.

China's attacks on key S&T problems during the Eighth 5-Year Plan will be concentrated on directional and key research topics in all realms that have a major influence on the overall situation in national economic and social development. The plan makes arrangements for more than 170 projects in the nine main realms of agriculture, resource exploration, important technical equipment, energy resources, communication, primary raw materials, machinery- electronics and emerging technology, light and textile industry, medicine and health, and the environment. The state plans to invest 3.5 billion yuan of its financial revenues. Attacks on key problems during the Eighth 5-Year Plan are a continuation and development of attacks on key problems during the Sixth 5-Year Plan and Seventh 5-Year Plan and they will be carried out by adhering to the spirit of seeking facts, reform, and innovation.

I. Guiding Principles and Key Points of Attack for Attacks on Key S&T Problems During the Eighth 5-Year Plan

A. Continue to adhere to the primary status of attacks on key problems in agricultural S&T. Providing food and clothing to 1.1 billion people is a big problem. The serious trends of excess population and relative reductions in the cultivated land area in China will continue for a substantial period of time, so we must rely on S&T to promote greater development of agriculture. The main things are quantitative increases in grain and cotton and improvement of quality, which also is related to rational development and comprehensive utilization of land, water, heat, and other natural resources. One focus of attacks on key problems in agricultural S&T during the Eighth 5-Year Plan is a resolute and unwavering focus on breeding improved varieties of primary crops and establishing a seed science system ranging from breeding research to improved variety breeding and extension. A second is a resolute focus on comprehensive improvement of moderate and low-yield areas for substantial increases in unit output levels. During the Eighth 5-Year Plan we must breed 250 improved varieties that can be extended over a large area, complete the fourth replacement generation of seeds for China's primary crops, and increase grain and cotton output by 8 to 10 percent. Improvement of moderate and low-yield regions should deal with different soil categories, establish 50 comprehensive experiment regions on the Huang-Huai [Huang He and Huai He] Plain, the Sanjiang [Three Rivers] Plain of northeast China, the loess plateau of northwest China, the red soil and hilly region of south China, and arid regions and some desertified regions of north China and do research on a full set of technologies for stabilizing and improving production potential. The corresponding arrangements should also be made for forestry, aquaculture, and animal husbandry S&T in attacks on key problems during the Eighth 5-Year Plan.

B. Make major efforts to promote continual renewal and equipment modernization for industrial and communication technology. We should use attacks on key problems during the Seventh 5-Year Plan as a basis for continuing to reinforce work to digest, absorb, and shift to domestic production for major imported technology and equipment and undertake new research on several key projects like desert petroleum exploration and extraction. Research on new technology and new equipment should start with the real needs of production and construction, adhere to the spirit of doing our own R&D as the main factor, develop toward larger scales, applicability, and batch production, and strive to catch up with international levels of the mid and late-1980's in certain fields. Energy conservation and reduced consumption should be the focus in providing several new technologies and new equipment for traditional industry to gradually change the situation of high energy consumption and low efficiency in China's industrial production. We must focus on petroleum and natural gas resource R&D and on comprehensive utilization of coal, natural gas, and non-ferrous metals. We should focus on market demand in China and foreign countries and develop several new products to improve our supply capabilities and earn foreign exchange, including high added value light and textile technology, the refined chemical industry, intensive processing of resources, and so on to provide technical reserves for product renewal and replacement.

C. Strive to develop electronics technology and other new technologies to upgrade traditional industry. Microelectronics, computers, electric power electronics, automation technology, and other things are the foundation for national economic modernization and the key to strength. We should use attacks on key S&T problems to make substantial breakthroughs during the Eighth 5-Year Plan in order to gradually change the situation of

electronic and information technology being restricted by people. We must adhere to the principle of a combined focus on basic and applied research. The focus for attacks on key S&T problems regarding microelectronics technology is on 1 to 2 μm integrated circuits, especially application-specific integrated circuits, and we should work on doing sub-μm integration technology. For computers, we should focus on key technologies for high-grade minicomputers and workstations, 32-bit microcomputers, and peripherals. In communications technology, we must complete attacks on key problems with DS 5 optical communications system and strive to place it into use. In addition, we must undertake research on digital mobile communications systems and integrated service digital networks. Numerical control technology should take aim at the objective of a shift to domestic production of middle and high-grade numerical control systems, establish our own editions, and match them up with machine tools. Industrial process automated control technology should develop toward projects and applications and move into batch production, and we should establish several automated production line demonstration projects in the electric power, metallurgy, chemical, construction materials, light and textile industry, and other industries. Electric power electronics technology is the key to upgrading enterprises, substantial reductions in energy resource and raw materials consumption, improvement in product quality, and reduced costs. We must make major advances and gain real benefits during the Eighth 5-Year Plan. We should also concentrate forces during the Eighth 5-Year Plan to work on microelectronics research base area construction and strive to develop electronics technology applications. We should also make the corresponding arrangements in plans for research and applications development in other new-tech realms like bioengineering, remote sensing, lasers, new materials, and so on and strive for substantial developments.

D. Strive to make major technical advances in the area of readjusting the relationship between man and nature. Focusing on projects to attack key problems in population, the environment, resources, and other areas is very important for promoting coordinated development of our economy and society. During the Eighth 5-Year Plan, the focus in the area of medicine and health should be on research regarding the prevention of major diseases and malignant tumors and on early diagnosis and early treatment, and on the development of several new types of drugs and medical instruments. In the area of environmental protection, we should continue to undertake research on purification technology and resource conversion technology for the atmosphere, contaminated water, and dangerous solid wastes. In the area of disaster prevention, the focus is on perfecting and improving projection and forecasting technology for disastrous weather and disastrous marine environments. Protection and rational development and utilization of resources and energy are important aspects of industrial progress as well as an important aspect of coordinating the relationship between man and nature, and we should pay sufficient attention and undertake the necessary research during the Eighth 5-Year Plan.

E. Focus on research on basic technology and base area construction. In the development of all industries, every one of them has several basic technologies and some are also used jointly by several industries. They have an extremely great relationship with improvement in production, technology, and industrial levels, and are an important part of plans to attack key problems, so they should receive attention. All categories of resource bases, databases, experimental base areas, and demonstration production lines are related to the reserve strengths of attacks on key S&T problems. Their construction is also extremely important, so we should continue to make appropriate arrangements in plans to attack key S&T problems to benefit the smooth development of overall activities to attack key problems.

II. Plans To Attack Key S&T Problems During the Eighth 5-Year Plan Have Several New Characteristics and Should Be Implemented With a Spirit of Seeking Facts, Reform, and Innovation

Completion of tasks to attack key S&T problems during the Eighth 5-Year Plan has major significance for achieving plans in the 10-year program and Eighth 5-Year Plan. They will lay a scientific and technical foundation for the second strategic objective in China's modernization and construction and involve work that concerns our overall strategy, so they should receive a high degree of attention from the relevant areas and departments. In the new situation, attacks on key problems during the Eighth 5-Year Plan have several of their own new characteristics, the most prominent of them being that we will start with the Eighth 5-Year Plan in forming a national planning model with a multilayer three-dimensional structure that is composed jointly of the state level, departmental and industrial level, and local level. It will replace the unilayer structural model of attacks on key S&T problems during the Sixth 5-Year Plan and Seventh 5-Year Plan which had only the state level. This is a reform to enrich and perfect the plan system. The advantage of a national plan to attack key S&T problems that is composed of three levels is that plans to attack key problems at different levels solve problems at different levels. The focus in attacks on key problems at the state level is on concentrating forces to solve major problems that have a comprehensive character in that they involve multiple regions and industries. There will be few but precise projects, crack S&T staffs, concentrated financial and material forces, and clear primary objectives of attack. Attacks on key problems at the industry level will have a prominent industrial focus and will select those S&T problems that play key roles in industrial development as breakthrough points. Some will may vows and easily achieve results. Regional level attacks on key problems will establish special plans to attack key problems based on the resource characteristics and current economic development situation of a particular region to organize forces for invigoration of a local economy. Implementation of

these plans to attack key problems will aid in fostering the initiative of all areas and all levels, and will aid in adaptation to China's planned commodity economy, so they are a rather good organizational form and operational mechanism for attacking key problems.

We must focus on the following principles to be able to complete the arduous tasks of attacking key problems during the Eighth 5-Year Plan:

1. We must use the ideology that "science and technology are the first force of production" to guide our practice in attacking key problems. For this reason, we must place S&T in a strategic position, we must slant capital and manpower toward S&T, and all aspects of reform must aid in attacks on key S&T problems and in the broad application of S&T achievements in production and construction. We must continue to make efforts at all levels in integration and conversion between S&T and the economy, place the shift to application and projects for S&T achievements and batch production in an important status, increase S&T investments, strengthen experimental measures, and have strict quality management to accelerate the conversion of S&T achievements into actual forces of production. All S&T personnel should have a clear understanding of their historical mission, actively dedicate themselves to the ranks attacking key problems, and dedicate their intelligence and skills.

2. Attacks on key problems must adhere to the principle of having prominent foci and close coordination. There must be distinctions by levels and proportions for high-tech, new-tech, and applied technology, and for basic research, applied research, and project development. We must use an overall concept to establish research foci and link together all categories of research to prevent the comprehensive pushes of the past that scattered and wasted capital, resources, and manpower. Within the scope of plans to attack key problems, the truth in implementation of the research arrangement of "using tasks to carry disciplines" has been proven to be extremely effective. It is a summarization of China's experiences in the successful development of the "three bombs and one satellite" and electron-positron collider projects. Accurate selection of objectives and focusing on attacking key problems will carry along the entire situation. Careful selection of topics can hit the mark on the crucial points in attacks on key problems, rational division of topics can provide clear trains of thought in attacks on key problems, and organized and coordinated battles can condense forces to produce more wisdom. All these things are essential to guarantee the success of attacks on key problems. Coordination of work in attacking key problems is also very important. One, we must properly coordinate state plans to attack key problems with industry and regional plans to attack key problems to make them systematic and consistent. Two, we must properly coordinate state plans to attack key problems with the "863 Plan", "Torch Plan", "Enterprise Technology Development Plan", "Spark Plan", "Achievements Extension Plan", and basic research plans so to make them interlinked, linked up, and mutually supplementary. Three, we must properly coordinate plans to attack key problems with all plans for the national economy so that they have matching arrangements and truly foster the role of S&T in promoting economic development.

3. Improve management of attacks on key problems, make work to attack key problems adapt to the overall trends of reform of the economic and S&T systems. In organizational management, we must implement management by levels. With the exception of a few key state-level projects that will be administered directly by the state, although most industrial and region-level research topics will be included in state plans, they will depend mainly on administration by industries and regions. In plan management, we should implement a rolling plan system to improve the situation of a poor ability to meet contingencies after plans are formulated. We should allow readjustment, supplementation, and revision of plans on the basis of the times or facts and we should be concerned with tracking subsequent work on achievements. In the arrangement of project tasks, we can implement a contractual responsibility system, bring in competitive mechanisms, and adhere to the principle of selecting the best. Implementing public solicitation of bids for projects can increase transparency, provide institutions of higher education, the Chinese Academy of Sciences [CAS], all industrial departments, the military industry system, enterprise groups, and local scientific research departments in all provinces and municipalities with opportunities and enthusiasm for competition and truly unearth superior quality forces. In expenditure management, continue to implement the principle of integrating compensated utilization of funds with allocations, perfect reform of the allocation system, and actively implement a budget system for project experiments. Facing the situation of continued intensification of reform of China's economic system and continued perfection of the dual-level financial system and contractual responsibility system, there will be a trend of diversification of funding sources for attacks on key S&T problems at all levels. Capital should be raised from a variety of areas to do scientific research. Besides state allocations, bank loans, and capital raised by industries, we should also induce the idle capital of society onto the track of relying on S&T progress to improve economic results and make it a source of funds for attacking key problems.

4. Organizing and mobilizing S&T staffs and fully fostering the initiative of S&T personnel are the keys to successful completion of tasks. China has five big S&T armies, central and local independent research academies and institutes, enterprises, institutions of higher education, the CAS, and the military industry system. They have 10.8 million S&T personnel in the natural sciences. Attacks on key problems during the Sixth 5-Year Plan and Seventh 5- Year Plan have proven that this is an S&T staff of good quality capable of assaulting fortified positions, and they are still the main force in

attacking key problems during the Eighth 5-Year Plan. The problem is organizing them well, fully fostering the special skills and knowledge and the characteristics of each of them so that the structure of attacking key problems that is formed of S&T forces at different levels of ability tends toward rationality and optimization to form the mutual supplementation of highly effective collective wisdom and strengths, and striving to reduce waste and internal consumption of skilled personnel. As for the S&T experts who lead projects, we must be pay attention to their views and respect their work so that they fulfill their duties and responsibilities and fully foster their skills. In attacking key problems during the Eighth 5-Year Plan, we should still pay attention to work to import knowledge from foreign countries. The nearly 10,000 S&T personnel involved in attacking key problems who came to visit from foreign countries and then returned home during the Seventh 5-Year Plan became a backbone force in attacks on key problems and made significant contributions to attacks on key problems. During the Eighth 5-Year Plan we will accelerate the pace of commercializing, industrializing, and internationalizing S&T achievements, and S&T work will move toward the world and orient toward modernization, so it is extremely necessary that we import knowledge to match up with China's attacks on key problems during the Eighth 5-Year Plan. Centered on plans to attack key problems, China will hold three types of training classes in foreign countries during the Eighth 5-Year Plan. They are a training class for personnel in programs and plans to attack key problems, a training class for personnel to manage the organization and implementation of projects to attack key problems, and a training class in international technology trade services. China will also select 30 projects to attack key problems for focused support and will send 1,000 people to foreign countries for advanced training and recruit 300 experts from foreign countries. Importing knowledge from foreign countries and tracking and inspecting the results will be included as a system in plans to attack key problems and become an important part of the plan.

Managing National Defense Research Institutes' Military and Civilian Products

92FE0359F Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 1, Jan 92 pp 19-21, 44

[Article by Ren Zhong [0117 6850] of Ministry of Aerospace Industry Institute 608: "A Preliminary Exploration of Military and Civilian Product Management Models for National Defense Scientific Research Institutes"]

[Text] [Abstract]

This article analyzes the contradictions that exist in managing the implementation of military and civilian product scientific research. It includes five primary models for military and civilian product scientific research management that have been implemented at the present time, the fully- bound model, the semi-bound model, the fully-open model, the dual-wheel model, and the encircled model, and it proposes several basic principles for selecting management models.

Key terms: conversion from military to civilian products, management model

With reform of the S&T system and a shift in the state's focus in economic construction, national defense scientific research institutes have basically formed a scientific research structure that is compatible with military and civilian products. How to better handle the relationship between military and civilian products and select an appropriate management model is a common question facing national defense scientific research institutes.

I. Contradictions in Management of Military and Civilian Product Scientific Research

Military product research and civilian product research differ in sources of tasks, research requirements, sales markets, allocation of benefits, and other areas. As a result, each has different management requirements. Since implementation of the "conversion from military to civilian products", research institutes have done a great deal of work in this area but even today they still are perplexed, as manifested primarily in:

1. The contradiction in personnel allocation. The development of high-tech civilian products and military product scientific research both involve considerable technical difficulty and both require crack personnel hardened in technology to take leading responsibility. Thus, if research institutes wish to combine both military and civilian product research and derive dual harvests, they must rationally allocate their limited key technical forces. This forms the contradiction in personnel allocation in research institutes.

2. The contradiction in arranging tasks. Most military product scientific research tasks in research institutes are directive-type tasks assigned by higher authorities, and some are even key state projects. These tasks have very strict requirements. However, the civilian product development tasks taken on by research institutes likewise cannot be neglected because of their very powerful market characteristics (some are key state or industry projects to attack key S&T problems). When arranging tasks for a "Sky 1" (military products) and "Ground 1" (civilian products), research institutes often fall into the contradiction of "dual swings".

3. The contradiction in work evaluations. Everyone knows that most scientific research regarding military products is in high-tech and incisive scientific realms. Because of the risk and exploratory nature, some projects may produce no major achievements even after several years of work. Research on civilian products is different, however. They usually have the objective of commercializing S&T achievements and require conservation of investments and quick results. Most are applied technologies, so-called "short, easy, and quick" projects. For

this reason, most civilian product projects are evaluated yearly and produce results each year, and some projects may even have extremely significant economic benefits. This often leads to several troublesome cases because of differences in evaluation standards for assessing accomplishments in work.

4. The contradiction in allocation of benefits. Because of funding reasons in military product scientific research, the bonuses received by scientific research personnel for their arduous work are mostly very low. However, the benefits for most civilian product development projects are quite significant, especially those projects that enjoy preferential policies from the state or local areas and can provide very substantial economic incomes. If an allocation method of "more allocations for more money earned" is adopted, the bonuses for personnel involved in civilian product development are often several times or several 10 times higher than for personnel involved in military product research. This gives comrades involved in military product research a psychological sense of imbalance and has a great effect on military product research. Moreover, if one simply adopts the method of "egalitarianism and indiscriminate transfer of resources" to deal with this question, the initiative of comrades involved in civilian product development obviously will be injured. For this reason, the contradiction in allocation of benefits has become the biggest problem in managing scientific research on military and civilian products.

5. The contradiction in development programs. Implementation of a "conversion from military to civilian products" in the national defense S&T industry is not an expedient measure. As a result, there is the question of civilian product development programs for a research institute. Examples including the establishment of civilian product industry and trade enterprises, construction of civilian product production lines, technical upgrading that is compatible with both military and civilian products, establishment and perfection of administrative mechanisms in research institutes, programs concerning civilian personnel specializations and trade-type personnel, and so on. Moreover, these things make it hard to avoid to a certain degree a mutual shock to military product scientific research programs.

Besides these five areas, there are also other contradictions like making arrangements to use general-purpose equipment, capital turnover, materials transfers and allocations, and other areas.

II. Some Primary Management Models Currently in Effect

Military industry scientific research has undergone nearly 10 years of exploration since implementing the "conversion from military to civilian products" and many management models have been form in the management of military and civilian product scientific research. The are five main types:

1. The fully-bound model. Research institutes fully bind military and civilian product research together for unified plan implementation, unified management evaluation, and unified bonus allocation. Work arrangements, division of benefits, and so on are completely identical for the two groups of personnel in military product and civilian product scientific research. Most of this category of research institutes focus on military products and have not formed an atmosphere of civilian product development or established civilian product management mechanisms. The advantage of this model is that it is conducive to centralized leadership and helps stabilize military product research. Its shortcoming is that it has limited strength for civilian product development and makes improvement difficult, or it interweaves military and civilian product research and puts management work in a hasty and disorderly state.

2. The semi-bound model. Military and civilian product research is linked in certain areas and separated in other areas. This is the semi-bound model. The primary mode is unified implementation of plans and separate allocation of bonuses. Research institutes concentrate on accepting projects from outside and unify the assignment of plans and organization for their implementation. They implement the allocation method of "bonuses for military products and proportional deductions for civilian products". Most of the research institutes in this category have equal military and civilian product tasks or slightly more military products than civilian ones, and they have a definite foundation in civilian product development but have not formed scale economies and do not have independent civilian product management mechanisms. Their advantages are that they centralize leadership and have differential management and play a substantial role in motivating employee initiative. Their disadvantages are unclear evaluations and the ease of shifting civilian product costs to military products.

3. The fully-open model. The fully-open model involves comprehensive opening up. The usual arrangement is "integration above, substance below". Research institutes carry out macro control and implement "dividing up the stoves to eat, integrated administration, contractual responsibility for profits" for lower levels. Most of the research institutes in this category have very few or even no military product tasks and are mainly involved in civilian product development and establishing trade enterprises. A research institute is a company or even several companies and each company is an economic entity. They are all integrated in dealing with the outside, have integrated bank accounts, and each company turns over specified profits to the institute. Their advantages are that basic levels are very active and employee initiative is fully fostered. Employees try in every way to establish companies and individual incomes are usually rather high. Their disadvantages are the appearance of a loss of macro control by the research institute and the basic levels are built on the economic stilts of the institute. A situation of institutes borrowing money from

basic levels to run things can even appear sometimes, which has negative effects on the overall development of research institutes.

4. The dual-wheel model. The dual-wheel model is a management form that is similar to the fully-bound model in that military and civilian product research are entirely independent and separate and the two wheels roll together. There are two completely independent systems in management mechanisms that separately assign plans, organize implementation, and make evaluations and allocations. For development, there are specialized civilian product development centers or civilian product research offices. In production there are specialized civilian product workshops or civilian product branch plants that build civilian product production lines. Most of the research institutes in this category have equal military and civilian product tasks and make long-term plans for civilian product development. The advantages of this model are that military and civilian product research are independent sectors that are not tied together and each does its own development, which can reduce many problems in management. Their disadvantage is poor joint use of scientific research forces and facilities. They are obviously not flexible enough in the areas of personnel and task adjustment and transfer. The specializations that scientific research personnel wish to study are not discarded and they can make it hard to make appropriate changes in income situations so that both are complete, which makes both groups of personnel apprehensive.

5. The encircled model. One foot placed at the center of the circle and one foot moving around the center of the circle is called the encircled model. Research institutes place military product research tasks in the central position and, with a prerequisite of ensuring military industry tasks, broadly undertake civilian product development. Military products are assigned as directive tasks and strictly evaluated. Each unit that assumes responsibility for civilian product tasks can also implement two-stage development and independently assume responsibility for projects from outside. All projects must be responsible to the plan management office and they must sign contractual responsibility contracts and implement deductions. At the end of the year, planning, scientific research, and financial organizations conduct three joint inspections of the military product tasks completion situations for each unit. Only when a unit has completed its military product tasks can it make deductions from the financial administration for that unit's civilian products. Otherwise, deductions are made from allocations. Those which complete them well can receive additional bonuses. This arrangement is called "seizing military products at two ends (beginning of year plans and end of year evaluations) with civilian products being given life in the middle (with the exception of the two ends, no restrictions on development of civilian products in the middle)." The income from military and civilian products in each unit are not given directly to personnel. Instead, secondary allocations are made by each unit according to its own circumstances to balance the contradiction between military and civilian products in their department. Most research institutes that have implemented this arrangement have plenty of military and civilian product tasks and are not willing to give up either of them. The advantage of this arrangement is that all units and employees in an institute have opportunities to assume responsibility for military products or civilian products and each unit can arrange for civilian product development according to its own advantages and how busy or idle it is. This motivates initiative at the basic level and does not lead to a loss of control. The research institute can proceed with the benefits of both military and civilian products and employee incomes are increased. Its disadvantages are that it is hard to balance the allocation of military product tasks and it is possible that unequal proportions may appear between military and civilian products in a unit. This requires planning departments to make an effort at greater balance when assigning tasks. The usual method is to treat some of the large civilian product projects in an institute as directive tasks and adjust them.

III. Basic Principles for Selecting Management Models

There is a great variety of names for military and civilian product scientific research management models in national defense scientific research institutes and each has its special characteristics. How can they be selected? We must begin with reality and adapt to conditions in each institute and we cannot be inflexible and rigid. Regardless of which type of model is chosen, however, all must observe the following basic principles.

1. Adherence to the principle of the socialist orientation. Adherence to the socialist orientation means adhering to the basic lines of "one center and two base points" under the leadership of the CPC, resolutely implementing all principles and policies of the party and state, orienting toward national defense construction and national economic construction, working around the center of economic construction, and accelerating the transfer of technology toward the realm of production. As socialist scientific research institutes, if they fail to consider China's overall situation and do not think in terms of the state's overall scientific research programs, and instead work toward immediate benefits and engage in various illegal administrative activities, they will lose the basic attributes of socialism, scientific research staffs may become lax, and scientific research ideologies may become disorderly. For this reason, when establishing a management model and strengthening management of scientific research, we must make adherence to the socialist orientation a basic principle. We must obey and serve the strategic foci of the party and state and correctly guide employees in taking the socialist road. In addition to accelerating national defense scientific research at present, they should also actively participate in the state's "Spark", "Torch", and other scientific research plans. They absolutely cannot be bent solely on profit and use the S&T they hold as capital for earning high remuneration from the state and the people.

2. The principle of promoting scientific research development. Developing scientific research involves the continual production of achievements, attacking the incisive areas of technology, and scaling the peaks of S&T in an effort to pursue and surpass advanced world S&T levels. The scientific research management model for national defense scientific research must help promote the development of scientific research and technical progress. National defense S&T falls within the scope of high-S&T and is an indicator of a country's overall national strengths. The development of military products must be based on modernization and embodied in a concentrated way in S&T progress. The development of civilian technology requires a concern for applicability and must embody advanced properties and develop high-level, high-quality, and high added-value high and new-tech products to form large forces of production. We should encourage and support scientific research personnel in becoming involved in high and new-tech development, formulate the corresponding protection policies, and prevent the superficial pursuit of economic benefits that involves working on several low technologies or redundant development.

3. The principle of "the military industry first, integrating military and civilian products". National defense research must always place military product research in the first position, resolutely make the military industry number one, and shoulder the heavy burden of national defense modernization and construction. At present, a changing international situation, hegemonism, and power politics continue to develop so there is an even greater need to pay attention to the development of national defense S&T and focus on military product research. At the same time, to meet the needs of reform of the S&T system and the shift in the state's strategic focus in economic construction, national defense research institutes must also orient toward economic construction, accelerate the transfer of technology into civilian realms, and resolutely take the development path of "integrating military and civilian products, integrating peacetime and war". For this reason, the scientific research management model of research institutes must focus on military product research, meet the requirement of "integrating military and civilian products", and truly form mechanisms that are compatible with both military and civilian products and strengthen our ability to make a transition from "peacetime to war".

4. The principle of dealing correctly with "three-way" interests. Management of military and civilian product research in research institutes must resolutely deal correctly with the relationships among the state, collectives, and employees. The principle of the state first, collectives next, and then individuals must be embodied in formulation of deduction proportions, compilation of contractual responsibility contracts, determination of task foci, formulation of development programs, and other areas. We absolutely cannot be unfair to the public and enrich individuals. Of course, neither can we damage the legitimate interests of employees. We must adhere to the socialist principle of "more pay for more work, distribution according to labor" and fully motivate the initiative of employees.

5. The principle of the scientific qualities of management. The scientific qualities of management are embodied primarily in advanced and rational management ideologies and management methods, smooth management channels and management relationships, flexible operation of management mechanisms, and so on. Concretely speaking, in systemic qualities, whether or not military and civilian products can develop in a coordinated manner and whether or not the structure of scientific research trends toward being rational; in comprehensive qualities, whether or not management organizations are crack quality and highly effective; in rationality, whether or not management organizations and management modes conform to the objective laws of scientific research work and whether or not the formulation of the related policies and stipulations conform to the party and state's principles and policies and the interests of employees; and in democratic qualities, whether or not the scientific research environment is relaxed and full of a democratic atmosphere, achieves equal discussion, has broad-based exchanges, allows each to air his views, and arouses their intellects will determine whether or not it is conducive to democratic management, respect for the wishes of employees, and protects the legitimate rights and interests of employees.

Study on Technological Progress of Machine-Building Enterprises in China

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[Text] [Abstract]

This topical group conducted a survey over 4 successive years of some large and medium-sized enterprises in China's machine-building industry as a basis for using methods that integrated quantitative analysis with qualitative inferences to study technical progress in enterprises and suggest some methods and ways to solve problems that can be adopted in the short term.

Key terms: machine-building industry, technical progress

I. Outline

A. The connotation of enterprise technical progress

The connotation of technical progress in enterprises can be expressed in various ways. We outlined it in four

content areas: 1) New product research and development and R&D on new design methods and design measures. 2) R&D on new technology and new technical equipment. 3) Modernization of all aspects of management work and management measures. 4) Education and training of all categories of employees to improve their quality and professional skills in all areas. These areas are interrelated organic entities that affect each other, but R&D activities can be viewed as the central content of technical progress.

B. The status of the machine-building and electronics industry in our national economy

The machine-building industry is a dominant industry that accounts for a large proportion and has profound effects on China's industry, and it occupies a decisive status in China's process of achieving modernization. In 1989, for example, the gross value of output in the machine-building and electronics industry accounted for 30 percent of China's industrial gross value of output and 25 percent of our net value of output. It accounted for 21 percent of our industrial profits and taxes, 27 percent of our total number of industrial employees, and 20 percent of the original total value of our industrial fixed assets (and 18 percent of the next value). Overall, the inputs and output of China's machine-building and electronics industry account for about one-fourth of all of China's industry. For a variety of reasons, however, there has been a substantial reduction every year in the past few years in the proportion of China's financial income that is accounted for by the taxes and profits turned over to higher authorities by the machine-building and electronics industry, dropping from 15 percent in 1985 to 11 percent in 1989.

The value of output in the machine-building and electronics industry accounts for about 35 percent of the gross value of industrial output on a world scale at present and for about 40 percent in the developed nations. China lags substantially behind this level. China has imported large amounts of machine-building and electronics products every year for the past 10 years and has had a foreign trade deficit of more than 10 billion yuan each year for machine-building and electronics products during this period. Most of the imported products are products that China does not have the ability to produce or cannot guarantee supplies. Low levels in the machine-building and electronics industry is one of the main factors restricting comprehensive, sustained, and stable development of China's economy. For this reason, there must be substantial development of China's machine-building and electronics industry for a considerable period into the future, and it should have an appropriate "lead period" relative to development of our overall national economy.

C. Changes in the product mix in the machine-building industry during the Seventh 5-Year Plan

Several major changes occurred during the Seventh 5-Year Plan in the product mix in the machine-building industry, the main ones being: 1) A stronger consciousness of combining service to heavy industry with service to agriculture, light industry, urban construction, the people's livelihood, and other areas and improvement in the ability to adapt to and track markets. 2) Significant accomplishments in exporting to earn foreign exchange, with a substantial increase in growth rates for exports of machine-building and electronics products at an average of 31 percent a year. 3) Significant reductions in consumption of energy and materials. 4) Rather substantial improvements in product level structures. 5) Relatively fast growth of some basic products and several emerging industry products.

However, many problems still exist in the product mix, the main ones being: 1) A lower rate of growth in products with a high technology content than the average rate of growth in the machine-building industry and no obvious changes in the extensive and inner-directed production management configuration; reductions each year in net output value rates, profit and tax rates on capital, technical progress product output value rates, and superior quality product output value rates; export products still dominated by energy and materials consuming products with low added value; substantial increases in the volume of exports of technology-intensive products but no increases in the proportion they account for in the total volume of exports of machine-building and electronics products, instead declining each year; a continued deficit between exports and imports. 2) Significant reductions in the pace of new product development. 3) Singularity of products with a small scope of possible users, which makes it hard to adapt to the development of diversification in market demand.

II. Sample Survey Statistics and Analysis for the Basic Situation in Technology Development Work in Large and Medium-Sized Enterprises

To gain an immediate understanding of and analyze the basic situation in enterprise technology development, we sent out survey questionnaires for 4 consecutive years starting in 1987 to about 300 enterprises each year (a random sample of the 1,068 key large enterprises in the former Ministry of Machine-Building Industry system) to conduct a survey of the relevant data. The questionnaire return rate was usually 50 to 70 percent. Because the technical forces and scientific research measures in medium-sized and small enterprises are extremely weak, activities in the machine-building industry that can truly be called technology development are basically concentrated in these large and medium-sized enterprises. For this reason, a survey and analysis of the basic situation in technology development in this category of enterprises has major significance for understanding the situation in the entire machine-building industry.

A. The basic economic situation in machine-building industry enterprises

Table 1. Basic Economic Situation

Indicator	1986	1987	1988	1989
Per capita value of output (current prices, yuan/person)	19,520	22,830	26,760	28,340
Per capita profits (current prices, yuan/person)	2,740	3,140	3,430	3,890
New product output value/Gross value of industrial output (percent)	9.08	22.72	8.33	12.75
Export product output value/Gross value of industrial output (percent)	2.03	2.38	3.56	4.93
Income from product sales/Gross value of industrial output (percent)	91.80	99.76	99.56	92.93
Gross profits/Gross value of industrial output (percent)	14.03	13.78	12.81	13.93
Actual profits retained by enterprises/Gross profits (percent)	27.07	39.05	29.93	19.23
Net value of fixed assets/Original value of fixed assets (percent)	57.32	54.19	56.33	56.23

The table above shows that, computed at current prices, there was sustained and stable growth in the two indices of per capita value of output and per capita profits from 1986 to 1989, with an average yearly growth rate of about 9 percent. Considering the rising price indices over the same period, however, this growth rate is very pessimistic.

New product development and production are direct reflections of an enterprise's technology development capabilities. The output value rate for new products is an important indicator of technical progress in an enterprise. In 1990, the State Planning Commission defined "new products". New products refer to "products that were developed and produced by adopting new technological principles and new design ideas among civilian industry products or products which make significant improvements compared to old products in structure, materials, technology, or certain other areas." We consistently employed the definition used in the 1986 industrial survey in doing our survey, which was that a new product means "a product that makes substantial improvements in the structure, function, technical characteristics, chemical components, and so on compared to the original product in one or more areas, or an innovative product that has never been produced before. It is a product that uses new technology from China or foreign countries for trial manufacture and has been placed into production, and which has had its specifications examined and accepted or is a new product of direct technical upgrading, and it must be advanced, practical, and have extension value." The time frame of a new product should be identical to relevant state tax exemption policies. There was a trend of rising value of output rates for new products from 1986 to 1989, but this increase was not that great given the low base figure conditions, and there were fluctuations. This group of data show that the value of output rate of new products in the machine-building industry lags substantially behind when compared with other industries in China. Enterprise technology development forces are weak or their role has not been fully fostered. The relevant data show that during the 3-year period from 1987 to 1989, the number of new product varieties with national properties as a proportion of new products in the machine-building industry showed a trend toward decline. This situation indicates that the machine-building industry is facing the problem of seriously inadequate development reserve strengths.

The value of output rate for export products is one yardstick used to assess the strength or weakness of an enterprise's ability to enter the international market, and it is also a reflection to a considerable extent of the quality of an enterprise's products. It should be explained that a substantial portion of the export products of machine-building industry enterprises are not technology-intensive products. There was a trend toward a stable increase in the value of output rate for export products from 1986 to 1989 but the base figure was rather low, lower even than average levels for the industry as a whole (estimated at about 7 percent). Large and medium-sized enterprises in the machine-building industry have no advantages in the area of exports, which is a reflection from one side of the less- than-rational export structure for China's machinery products. The newness coefficient of fixed assets (net value of fixed assets/original value of fixed assets) is an important indicator of production equipment levels in industrial enterprises. In a situation of too-low depreciation rates (about 4 percent) in the sample enterprises, the newness

coefficient of fixed assets was obviously too low, which indicates that there were no improvements in the situation of equipment aging during the Seventh 5-Year Plan. This directly affects improvement in the quality of enterprise products and affects technical progress levels in enterprises. The product sales rate index was lower in 1986 than in 1989, which is a direct reflection of the two instances of austerity during the Seventh 5-Year Plan. Moreover, the results of a sample survey done in early 1990 show that product stocks in the sample enterprises at the end of 1989 were equal to 30 percent of the gross value of output during that year, so the situation is rather serious and it was not resolved during 1990. The value of output profit rate (gross profits/gross value of industrial output) basically fluctuated around 13 percent from 1986 to 1989. There was, however, a substantial reduction for 2 consecutive years beginning 1988 in the ratio of enterprise actual retained profits to gross profits, which shows that the burden on enterprises has become even heavier. This will inevitably have negative effects on enterprise reserve strengths.

B. The technology development expenditure situation in machine-building industry enterprises

Table 2. The Technology Development Expenditure Situation (percent)

Indicator	1986	1987	1988	1989
Technology development expenditures/Income from product sales	1.41	1.17	1.37	1.37
Allocations from higher levels/Technology development expenditures	8.22	5.46	7.17	8.93
Trial manufacture funds/Technology development expenditures	14.25	16.18	17.93	24.54
Entering costs/Technology development expenditures	67.24	63.71	63.87	50.09
Entering costs/Income from product sales	0.95	0.75	0.88	0.81
Outlays on capital construction and technical upgrading projects to place development projects into operation/Technology development expenditures	2.12	2.92	1.63	1.59

Technology development expenditures include allocations from higher authorities, bank loans, entry capital, trial manufacture funds, and so on. While there have been substantial changes in the past several years in the external environment of enterprises, the ratio of technology development expenditures to income from sales has held stable overall. This indicates that enterprises have acknowledged the importance of technology development and that they have acted. On the surface, the ratio of technology development expenditures to product sales volume during the past several years has always been above 1 percent, but this may actually be a false impression. Because the annual reports of the Ministry of Machine-Building and Electronics Industry provide a less than accurate interpretation of the concept of technology development, there is not a consistent understanding of this concept by all regions and all departments. They frequently treat technical upgrading and even capital construction investments as (or partially as) technology development expenditures. This proportion is always below 1 percent in several enterprises with better management, which shows that insufficient technology development expenditures is still a problem that deserves consideration.

Entry costs are an important part of enterprise technology development expenditures. From what we could obtain regarding this portion of expenditures, however, rather high-level statistical data show that they are still less than 1 percent at the present time. This proportion is much lower for the industry as a whole. Thus, it would be best not to make too high an estimate of this. Moreover, according to the newest statistical data, profits retained by enterprises in the Ministry of Machine-Building and Electronics Industry system (which includes machinery, electronics, ordnance, and ships) in 1990 were just 1.4 percent of the income from product sales. In this type of situation, it can be expected that most enterprises will be even more likely to find their abilities falling short of their wishes regarding technology development work. The ratio between capital construction and technical upgrading expenditures to place technology development projects into operation and technology development expenditures is obviously too low, and this is undoubtedly one of the main reasons for the difficulty in commercializing S&T achievements. After 1988, in a situation of relative stability in technology development expenditures, there was a further reduction in the corresponding capital construction expenditures. This was one manifestation of the less-than-optimum environment and short-term behavior in enterprises. This situation appeared more or less simultaneously with the universal implementation of the contractual responsibility system, so it cannot be entirely unrelated.

C. The engineering and technical personnel situation in machine-building industry enterprises

Table 3. Engineering and Technical Personnel Situation (percent)

Indicator	1986	1987	1988	1989
Engineering and technical personnel/Total number of employees	9.27	9.42	9.75	9.98
Engineering and technical personnel involved in development/Total number of engineering and technical personnel	19.63	25.92	25.25	32.99
Additions to engineering and technical personnel each year/Total number of engineering and technical personnel	8.94	10.54	12.06	7.25
Engineering and technical personnel entering/Engineering and technical personnel leaving	58.00	73.00	48.35	37.43
Number of new workers added each year/Total number of employees	4.33	2.84	3.80	2.96

People are the main factor in enterprise technical progress, especially engineering and technical personnel. The table above shows that the ratio of engineering and technical personnel to the total number of employees in large and medium-sized enterprises in the machine-building industry is about 10 percent. This is a rather high proportion compared to other industries in China. Fully fostering the role of these personnel would play an enormous role in promoting technical progress in enterprises. Two points regarding changes in enterprise engineering and technical personnel deserve attention. One is that the ratio of additions to engineering and technical personnel each year to the total number of engineering and technical personnel was always greater than the ratio of new workers added each year to the total number of employees, which shows that the structure of enterprise employees is developing in a direction that is favorable for technical progress in enterprises. The second is that the number of engineering and technical personnel leaving was consistently greater than the number of people entering, which is a "reverse flow" that deserves attention.

Several problems were also discovered in on-site surveys. 1) Few engineering and technical personnel are actually involved in technology development. The data show that personnel involved in technology development generally account for about one-fifth to one-third of technical personnel. If converted according to the amount of work done on technology development activities, this ratio would be much lower. Many engineering and technical personnel are involved in work that is not closely related to technology. 2) The overall situation is that the initiative of engineering and technical personnel and technical workers is far from being fully fostered. If we cannot find a reasonable way to deal with this, talk of technical progress in enterprises is meaningless.

D. The situation for technology development projects in machine-building industry enterprises (percent)

Table 4. The Situation for Technology Development Projects

Projects assigned by higher authorities/Total number of projects	35.29	28.23	32.68	32.81
Projects selected by enterprises themselves/Total number of projects	59.06	65.51	62.39	62.04
Horizontally commissioned projects/Total number of projects	5.62	6.26	4.93	5.15
Projects that depend entirely on forces in a particular plant for development/Total number of projects	80.85	84.93	84.25	83.43

Table 4. The Situation for Technology Development Projects (continued)

Projects developed cooperatively with relevant research units/Total number of projects	8.29	8.39	7.69	6.70
Projects developed cooperatively with relevant institutions of higher education/Total number of projects	3.88	3.26	3.96	6.61
Projects developed cooperatively with relevant enterprises/Total number of projects	5.53	3.42	4.10	3.26
Number of projects completed at year's end/Total number of projects	51.53	51.27	53.88	57.05
Number of projects placed into operation/Total number of projects	39.40	36.33	36.30	44.23
Number of projects placed into operation/Number of projects completed at year's end	76.46	70.86	67.37	77.53

The data from statistical analysis of each of the "projects" are stable overall with little variation. As for project sources, more than 60 percent were selected by enterprises themselves, with those assigned by higher authorities coming in second. Horizontal relationships among enterprises were negligible. This shows a rather serious situation of technological blockades among enterprises, which is another important factor that affects technical progress in enterprises. As for those assuming responsibility for projects, more than 80 percent relied entirely on forces in enterprises themselves. The proportions for various types of cooperative arrangements were all rather low, only about 10 percent. This shows that, overall, technology development activities in enterprises are still constrained in a closed environment, which is another important factor that restricts improvement of enterprise technology levels. The ratio of the number of projects placed into operation to the number of projects completed by year's end, or the "operationalization rate", is one basis for evaluating commercialization of technology development achievements in enterprises. The rather high value for this 4-year period indicates the characteristic of "some who shoot arrows" in enterprise project establishment, and it is a reflection of the problems of relatively few advance research projects and inadequate technical reserves in enterprises.

We also learned through the survey that: 1) The average schedule for technology development projects in enterprises at present is about 20 months. For China's machine-building industry, these are average or even slightly small projects. For various reasons, technology development activities in enterprises at the present time mainly involve "short, smooth, and fast" projects and their ability to develop large-scale sets of projects is still extremely weak. According to the relevant data and the situation in our survey, development schedules for new products in China's machine- building industry are far longer than in the industrially developed countries. Regular products take about 5 years from scientific research to operationalization and large products take 8 to 10 years. The time required for large sets of equipment is often even longer. 2) According to the relevant data, the commercial success rate of enterprise technology development projects in the industrially developed nations is generally 20 to 30 percent. This figure is less than 10 percent for our development projects, however, because of projects that never achieve operationalization due to market demand factors and because of projects where research stops because of factors in the area of technology. In contrast, an overly high "success rate" indicates that our development projects lag substantially behind technology development projects carried out by enterprises in industrially developed countries in the area of qualitative content. At present, if the technology development projects in China's enterprises were evaluated according to a strict definition of "technology development", most would not be called "technology development". A substantial portion of them could only be considered "small revisions and small changes" or regular designs. We have many "model change" products and few "replacement" products. The same is true for technology development.

In summary, we can form this view: economic work during the Seventh 5-Year Plan started in austerity and ended in austerity, with rapid development in the middle. A "too cold" and "too hot" external environment were both unfavorable for technology development work in enterprises. Despite this, definite accomplishments were made through a great deal of work in this area in large and medium-sized enterprises in the

machine-building and electronics industry, but many problems also existed at the same time.

III. Macro Factors Affecting the Formation of Technology Development Mechanisms in Enterprises

Since the fourth quarter of 1988, the implementation of an austerity policy in the area of economic construction and the sustained impact of this policy pushed development of our national economy into a "valley" for a period of time. During the past 2 years, there have been substantial increases in the extent of losses and total losses as well as substantial slides in economic benefits in large and medium-sized enterprises, which are important pillars of our national economy. Why has the vitality that large and medium-sized enterprises should have not become fully apparent so far? We feel it is due mainly to the continued impact even today of the old economic system and to certain mistakes by the state in the area of macro decision making which have consistently made it hard to improve the external environment of large and medium-sized enterprises. Moreover, such an external environment has a negative impact that cannot be ignored, on production management in enterprises as well as on technical progress in enterprises.

A. The old economic system still has considerable influence

The restrictions on technical progress in enterprises by the old economic system can be outlined in several areas: 1) The extensive expanded reproduction development model has reduced overall returns to investments in economic construction and reduced the demand for technical progress in enterprises. 2) High tax rates have made it impossible for enterprises to have true self-upgrading and self-development capabilities. 3) Serious aging of fixed assets has greatly restricted enterprise improvement of product quality and development of high-level new products. 4) The irrational price system is a direct factor that obstructs new product development. 5) Existing plan evaluation methods focused on value of output and amount of output do not assist technical progress in enterprises.

B. Negative influences of the external environment continue to exist

In 1986, to analyze the problems facing enterprises in the areas of production and development activities, we drafted a "primary and secondary sequential ranking" of certain problems in enterprises at that time that were felt to be the thorniest and had direct effects on enterprises, which were mainly problems in the area of the external environment, and we consulted with the leaders of several enterprises. We also carried out induction and ordering of feedback opinions using the (Deerfei) method. The result was this ranking of thorny problems: 1) The problem of raising capital for production, capital construction, and technical upgrading; 2) The problem of motivating employee enthusiasm for production; 3) The problem of raw materials, parts and components, and energy resource supplies; 4) The technology problem and the organizational management problem in technical upgrading, technical measures, and new product development. 5) The product price problem. 6) The product sales avenues problem. In addition, enterprise leaders also suggested other difficulties. Opinions were relatively concentrated on: frequent policy changes, the failure to implement the question of expanding the rights of enterprises for a long time, excessive administrative interference by higher authorities, overstaffing, and so on.

In the first half of 1988, we consulted leaders in several enterprises about the same problems. The results were that after 2 years, with the exception of most enterprises which were facing the problem of "impeded product sales avenues" having the feeling that there "had been some improvement" (this improvement was directly related to the overheated economy and loss of control of the scale of capital construction at that time. Moreover, starting with the last half of 1988, this "improvement" began to move in a reverse direction due to the start of implementing "austerity" policies and this continued until now. Impeded product sales avenues and unusual overstocks again became a prominent problem that caused problems for normal production and management in most enterprises), more than half of the enterprises felt that the "situation had become more serious" for the remaining five problems. The situation facing the entire machine-building industry in 1990 was all the more serious. Obviously, these problems continue to exist and it is very possible that most enterprises have seen the "situation become more serious". They find it very hard to be able to convert "pressure" into "motive power" and it is very easy for the bitter external environment to distort the behavior of these enterprises. The phenomenon of "growing short-term behavior in enterprises" has become common and more serious over the past 2 years, and this is certainly not an accidental phenomenon. Overall, the negative effects of a less than optimum external environment on technical progress work in enterprises exceed the positive effects and the resistance it may create resistance may be greater than the motive power it creates.

C. Several problems that became more acute during the Seventh 5-Year Plan

While fully affirming the enormous accomplishments made by the machine- building industry during the Seventh 5-Year Plan, we should also do more intensive analysis of the problems that exist. We feel that the macro factors that became more acute during the Seventh 5-Year Plan and which have a negative impact on technical progress mechanisms in machine-building industry enterprises are mainly the following points:

1. Because of the effects of long-term barriers between levels, departments, and regions and other factors, the fatal flaw in China's machine-building industry is "scattering". During the Seventh 5-Year Plan, due to the effects of an overheated economy and "dividing up the

stoves to eat", this has expanded further in the machine-building and electronics industry. From another perspective, among China's 500 biggest industrial enterprises ranked according to volume of sales in 1989, one instruments enterprise, three heavy mining equipment enterprises, and five power plant equipment enterprises were at the top, while not a single enterprise in the machine tool industry, which occupies an extremely important status in the machine-building industry, was selected.

Redundant construction, redundant deployments, and a trend toward similarity in industrial structures among regions have made the structural contradiction in the machine-building and electronics industry that was already characterized by extremely acute "scattering" even more acute. With a loss of macro control first and then a loss of micro coordination, the low levels and poor results in the machine-building and electronics industry that result from "scattering" can now be said to be even harder to correct. Because the overall situation in the machine-building and electronics industry is one of large numbers of people and poor results, most enterprises faced the problems of insufficient tasks and abnormal growth in product stocks following the initiation of "improvement and rectification" work in the fourth quarter of 1988. The problems of a too-large overall scale and excess capacity were again revealed in a comprehensive way. We feel that it deserves special explanation here that a too-large "overall scale" is due to too many low-quality enterprises and that the "excess" in "excess capacity" is mainly backward forces of production. In contrast, an "excess" of more advanced production capacity was caused mainly by certain mistakes in the state's macro management such as "excess" production capacity for large sets of power generation equipment, which is directly related to the state's imports of large amounts of similar products.

2. Although there was a reduction in the profits and taxes turned over to higher financial administrations by enterprises during the Seventh 5-Year Plan as a part of their sales volume, their real burden has gradually become heavier. This is due mainly to: 1) Ever-smaller supplies within plans received from the state by large and medium-sized enterprises. Enterprises have found it increasingly difficult to digest the sustained substantial price increases for all categories of the means of production and are only able to "buy and sell at high prices". In a seller's market, this can further exacerbate the disorder in the price system. In a buyer's market, it makes existence difficult for a substantial number of enterprises. 2) Because quotas of circulating capital have not changed for many years, the scale of production has expanded each year. Moreover, it is hard for enterprises to increase the capital they hold themselves for various reasons and enterprises have come to rely to a growing degree on loans for production capital for the past several years, so there has been an abrupt increase in their interest burden. Surveys by relevant departments indicate that enterprise outlays for this item increased by an average yearly rate of more than 40 percent from 1985 to 1989. Although the state has adjusted interest rates downward in 1991, it still cannot reverse the trend toward "yearly increases" in the burden on enterprises in this area. 3) Instead of repeatedly prohibiting funds, fees, apportionments, and so on under various names, they have continued to increase. 4) The sustained drop in enterprise results in combination with the long-term capital shortage has ultimately resulted in "triangular debt" on an unprecedentedly broad scale. If we fail to adopt more effective measures, this will inevitably become yet another persistent ailment affecting the healthy development of China's economy.

3. During the last half of 1987, with a background of continually worsening inflation, hesitation in readjustment of the industrial structure, enterprise difficulties in improving results, and other things that were extremely unfavorable to economic development, implementation of the enterprise "contractual responsibility management system" as a major state decision was accelerated. Practice has proven that when all policies, laws, and regulations are incomplete and macro management mechanisms are not yet mature, there are many problems in attempts to use a contractual responsibility management system to achieve a series of goals in reform of the economic system. The reasons are that: 1) In a commodity economy, ownership rights and administrative rights over the means of production cannot be completely separated. Ownership rights determine the motive power and objectives of administrative rights, while administrative rights can create and increase the value of ownership rights in reproduction. If enterprises only have administrative rights, they inevitably are concerned only with short-term interests and have no enthusiasm for renewing and increasing the value of state assets. 2) State-run enterprises at present lack true property owners. Government administration departments are merely the "fictitious owners" of property in enterprises owned by the whole people, so there is no one concerned with property accumulation or property income. After implementation of a contractual responsibility system, ownership rights are still absent to a substantial degree. There are now several ways to establish state-owned property management organizations but they are still to a substantial degree "stacked on top of" the old system, making it very hard to solve the important problem of "empty property". Both of these points inevitably have an indirect negative impact on technical progress in enterprises. 3) The common laws of the "contractual responsibility system" and the commodity economy are in opposition. In a commodity economy, prices change while tax rates are relatively fixed. Changing prices cause resource deployments to become more optimum and relative stability in tax rates guarantees equality of opportunity and fair competition. Compared to this, however, the contractual responsibility system has many prices set by the state and it is hard to avoid them becoming rigid. Tax rates are more elastic, so contractual responsibility for profits and taxes actually involves one rate for each case. This makes it hard to use price signals to achieve optimum resource deployments

and a situation of fair competition, the most fundamental external condition for promoting technical progress in enterprises, cannot be formed, making it hard to avoid phenomena like "whipping fast oxen" [excessive burden on better enterprises], protecting the backward, and so on.

Practice shows that what enterprise leaders get following enterprise contractual responsibility is not administrative rights but merely one part of administrative rights, which is management rights. Neither can they achieve complete administrative rights before major breakthroughs are made in reform of the economic system. Determination of base figures for contractual responsibility is not scientific, and after contracts are signed changes in the administrative environment make it hard to achieve rational reflections and readjustments in contracts. Contractual responsibility contracts can only stipulate requirements for enterprises in creating fixed assets during the term of the contract but cannot provide clear requirements for technical progress, technology development, and other hard-to-quantify activities in enterprises, so there is no way to restrain short-term behavior in enterprises. Contractual responsibility has a phased quality while enterprise development is continuous. The period of contractual responsibility is usually 3 to 4 years, so talk of long-term development is meaningless for the machine-building industry. A new product that is only slightly complicated takes a much longer period of time to be developed, go into production, and earn a profit than the term of contractual responsibility. These defects in the enterprise contractual responsibility system itself are hard to "perfect". During the last half of 1990, enterprises in many regions were truly at the point of linking their first round of contractual responsibility to the next round of contractual responsibility. Apparently, work to sign contractual responsibility contracts did not proceed smoothly. Obviously, if we continue signing contracts based on the idea of "yearly increases in profits and taxes turned over to higher authorities", a substantial number of enterprises will find this hard to do. If we make "readjustments" based on the economic situation in 1989 and 1990, meaning downward adjustment of contractual responsibility base figures, this would violate the original intent in implementation of the "contractual responsibility system".

4. Technical progress at appropriate levels and on suitable scales is an important way for China's enterprises to accelerate the pace of technical progress and accelerate product renewal and replacement. The reason for this is that there has been no significant improvement in the technology development capabilities, market contingency capabilities, and international competitiveness of China's enterprises. Improvements in technical levels in China's machine-building and electronics industry depends mainly on the configuration of technology imports, and there have been no fundamental changes. During the Seventh 5-Year Plan, because of insufficient sensitivity to both foreign exchange and domestic currency, expenditure levels for technology imports were lower than levels during the Sixth 5-Year Plan. In this way, while some control was attained over redundant imports and blind imports, necessary technology imports were also restricted. At the same time, there was no change in the situation of "importing when there is money but having no money for digestion". As time passes, the technology that was imported mainly during the Sixth 5-Year Plan will rapidly lose its advanced qualities. The relevant data indicate that of the more than 1,000 advanced technology items imported from foreign countries over a 10-year period after 1978, about one-third were at advanced levels of the early 1980's in foreign countries and about two-thirds were at 1970's levels. Moreover, less than two-thirds of these technologies have achieved batch production and trial manufacture of prototypes to date. Digestion and absorption of imported technology must have a corresponding foundation of technical levels and development capabilities. However, the formation of these "corresponding technical levels and development capabilities" requires substantial investments at a cost that is often far greater than that to import the technology itself. Thus, if there are no substantial readjustments in state policies in the area of supporting and encouraging digestion and absorption, it will be hard to make major breakthroughs in digestion and absorption work and hard to avoid a situation of "taking turns at importing" for a period into the future.

IV. Policies To Promote Technical Progress in Enterprises and Implementation Results

Since 1984, and especially since the announcement of the decisions on reform of the S&T system and the economic system, the state has announced certain policies to promote technical progress in enterprises.

A. Policies concerning the inclusion of technology development expenditures in costs

1. Content: For expenditures to purchase testing instrument, experimental facilities, and key equipment used in trial manufacture with a unit value of less than 50,000 yuan that are necessary for developing new products and new technologies, relatively small numbers can be allocated to current year costs while larger numbers can be allocated by enterprises to new product costs or total product costs over 3 to 5 years. In all cases where this method is implemented, the method of setting aside 1 percent from the volume of sales as a technology development fund is not implemented.

2. Results: Including technology development expenditures in costs is an important way at present for enterprises to raise technology development funds. Enterprises have greater flexibility after implementing this provision. The survey showed, however, that large and medium-sized enterprises were mainly restricted by economic conditions, so the development expenditures included in costs were less than 1 percent of the volume of product sales. Total development expenditures (which also include allocations from higher authorities, bank

loans, new product trial manufacture funds taken out of enterprise retained profits, and so on) were also just slightly more than 1 percent.

B. Policies concerning further expansion of enterprise decision making rights

1. Content: Enterprises can take their retained capital earnings and establish production development funds, new product trial manufacture funds, reserve funds, employee welfare funds, and bonus funds according to proportions stipulated by administrative departments and they have the authority to make their own allocations and uses. The first three funds can be integrated with depreciation funds and major overhaul funds to make unified arrangements for rational utilization.

2. Results: The documents clarified the uses for enterprise retained profits, and all areas also made stipulations regarding the proportions for each category of fund. The survey showed, however, that a substantial number of enterprises did not use their new product development and trial manufacture funds or did not use them in their entirety for new product development and trial manufacture. The main reason was that the enterprises were restricted by contractual responsibility indices. After making their payments to higher authorities and meeting the welfare requirements of their employees, there was nothing left.

C. Policies concerning tax preferences for new products

1. Content: All new products that are manufactured on a trial basis for the first time in China and which have been included in State Science and Technology Commission or State Economic Commission trial manufacture plans or which have been inspected and certified by the State Economic Commission or State Science and Technology Commission are exempted from the product tax and added value tax for 3 years from the day the trial manufactured products are sold. New products included in trial manufacture plans of ministries of the State Council or provinces, autonomous regions, and municipalities directly under the central government and that are sold during the trial manufacture period should be exempted from product taxes and added value taxes according to different circumstances for 1 to 2 years.

2. Results: Tax reduction and exemption policies for new products played a rather substantial role for a while in spurring enterprises to develop new products. The problems lie in: 1) There are differences in each place regarding the extent to which they have grasped tax reduction and exemption policies. 2) Because of the state's financial problems, the method used at present is first to determine the total amount for tax reductions and exemptions and then divide the total amount among areas. Local areas also often divide the total amount of tax exemptions among different industries. This increases the difficulty and side-effects when implementing tax reduction and exemption policies. 3) The widespread implementation of the contractual responsibility system has directly linked the incomes of enterprise employees with profits and taxes turned over to higher authorities. If there are tax exemptions, this naturally affects the completion of their profit and tax indices, which in turn affects employee interests, so many enterprises are unwilling to apply for reductions and exemptions. Because policies are not coordinated, this policy which should play a rather large role now finds it hard to play the role it should.

D. Policies concerning turning over all depreciation funds to enterprises

1. Content: The 30 percent of depreciation funds now concentrated in part in the hands of higher authorities should be turned over to enterprises.

2. Results: After this regulation was announced in a document, it was basically implemented in most regions. Apparently, the situation has now been reversed in certain regions.

E. Policies concerning reduction and regulation of taxes

1. Content: Taxes are readjusted and regulated to strengthen the self- upgrading capabilities of enterprises. Advanced enterprises with good economic results and high regulated taxes are given reductions and exemptions of regulation taxes in a planned and phased manner.

2. Results: The tax rate for regulated taxes have been reduced or even eliminated. After universal implementation of the "contractual responsibility system", however, this preferential policy is not very significant.

F. Policies concerning administration rights for dealing directly with foreign countries

1. Content: Some large enterprises are given administration rights for dealing directly with foreign countries. A small number of enterprises were first selected for trial implementation....

2. Results: Some large enterprises are given administrative rights to deal directly with foreign countries and this has played a substantial role in promoting exports of electromechanical products. Very few enterprises have this right, however, and the various relationships involved in foreign trade work are far from being straightened out. As a result, the economic results of product exports in most enterprises responsible for export tasks are not very high and it has not been easy to motivate their initiative for exports as a result. It should be pointed out that this policy basically concerns several shallow level and local issues in China's economic work and the methods are characterized merely by "transferring tax reductions". Moreover, no policies of greater importance have appeared at the state level since 1988. There are two main reasons for the difficulty in honoring the preferential policies the state has given to enterprises. One is that, as mentioned previously, policies are not

coordinated or policies are mutually contradictory. A second reason is that several policies with longer-term objectives like policies to strengthen horizontal relationships among enterprises, establish enterprise groups, and move research units into enterprises have met with excessive resistance in practice because of the number of fundamental questions they concern.

V. Ideas on the Issue of Intensifying Reform From the Perspective of Enterprise Technical Progress

A. The relationships of strength, motive force, and vitality

For the past several years, following the proposal of the guiding ideology of "economic construction should rely on S&T, S&T should be oriented toward economic construction", the issue of technical progress in enterprises has now attracted the attention of the state and is being embodied in certain policy areas. Although there has been a great momentum of public opinion on solving the problems that exist in enterprise technical progress, the policy measures actually adopted are still very limited. The gap between technical levels in China's enterprises and advanced world levels continues to widen. The basic cause of slow technical progress in China's enterprises is that enterprises still lack the strength and motive force for technical progress.

The strength of technical progress refers to the finances that enterprises can allocate themselves, the number and levels of the equipment they have, and the innovative labor that can be done by all categories of specialized personnel (including engineering and technical personnel, technical workers, and management personnel) in their involvement in technology development and technical upgrading. The motive force of technical progress is composed of two parts, "internal motive force" and "external motive force". The source of internal motive force is an enterprise as an economic entity in its natural pursuit of over-quota profits. Using technical progress is often the best way to achieve this pursuit. External motive force comes mainly from the pressure of market competition. Under certain conditions, administrative intervention and regulation and control measures in the economic area can also form limited external motive force (pressure) for enterprises. Strength and motive force can affect, promote, or restrict each other, but they cannot replace each other. Integration of strength and motive force is the vitality of an enterprise. For the past several years, if we acknowledge our mistakes, the main point is that we have said too much and done too little regarding the basic issue of "invigorating enterprises" and that most understandings of "vitality" are biased.

B. The formational conditions of technical progress mechanisms in enterprises

Several basic conditions are required for the formation of excellent enterprise technical progress mechanisms. The main ones are: 1) The state's economic activities must be orderly before there can be stability. Moreover, only under relatively stable conditions can economic construction truly achieve development, so "order" is the basis for "stability" and "stability" is the basis for development. 2) Only when there is stable and sustained development of the economy can we effectively promote the formation of technical progress mechanisms in enterprises. Thus, the formation of technical progress mechanisms in enterprises first of all requires economic development as a condition. Although technical progress can serve economic development and improve the results and quality of economic development, in a situation of poor economic operational mechanisms we cannot hope to use technical progress to promote development of the economy as a whole. 3) Only by continually intensifying enterprise economic development can enterprises have the strength for technical progress and create the motive force for technical progress. 4) The behavior of enterprises is determined to a substantial degree by the environment they are in. Thus, the focus on intensified enterprise reform should be placed on macro questions outside of enterprises. Moreover, the responsibility for formulating and readjusting the related policies and for supervising the conditions of their implementation lies first of all in government organizations at the state level.

C. High outputs are only possible with high inputs

Several points of enlightenment can be gained from the successful development of many enterprises in foreign countries: 1) High outputs are only possible with high inputs (mainly high inputs in the areas of scientific research and technical upgrading). The relevant data show that the capital inputs of enterprises in the area of scientific research in many developed countries at present are now significantly higher than their capital investments in purchasing equipment. This trend of change should attract a high degree of attention from us. 2) Technical progress in enterprises is a gradual and accumulative process. We do not have the conditions now for rapidly reducing our lag behind the developed countries in the areas of economic strengths and S&T levels. We must acknowledge this fact, not attempt to take shortcuts, and start solidly from the foundation. We cannot be negative or pessimistic about this question and feel that we can obtain great returns from merely spending a little money or making a few readjustments in policies. This is also unrealistic and useless.

D. We must increase our concern for research on "people"

In research on various policies regarding economic development over the past several years, our research on "people" appears to have been extremely weak. Actually, no other factor has as great or as direct an influence on economic development than people themselves. Motivating the initiative and creativity of engineering and technical personnel and technical workers is a fundamental condition for promoting enterprise technical progress. Many difficulties and problems have accumulated in this area and it can be said that they are more

difficult to resolve than funds, equipment, and so on. Of the main problems that exist in this area, one is a relative shortage of engineering and technical personnel. A second is a too-low proportion of engineering and technical personnel involved in research, development, and similar work. A third is the difficulty in reversing the situation of personnel "faults" [duan ceng 2451 1461—geological fault]. Supplementation of successor forces has been continually subjected to various types of shocks. This concerns questions in areas like wages, bonuses, housing, and so on, and it concerns questions in areas like personnel utilization and arrangements, evaluation of job titles, continuing education, and so on. Although the proportion of engineering and technical personnel in enterprises cannot be considered high, they are not few in terms of "absolute numbers". Many large key enterprises have more engineering and technical personnel than many specialized research organizations. The degree and strength of employee enthusiasm for production and creativity, and their sense of responsibility are extremely closely related to changes in their standard of living. Overall, there have been some improvements in employee living standards over the past several years. In this type of situation, the main reasons for a relatively universal reduction in the enthusiasm for production of employees are "unfair allocation" and "improper atmospheres".

E. A comprehensive consideration of deep-level issues in the area of systems

Today, good promotion of technical progress in enterprises and good invigoration of large and medium-sized enterprises are both related to several deep-level issues in the area of systems. There are 10 issues at present that must be addressed: 1) The issue of government functions and the issue of macro monitoring of the operational state of the national economy. 2) The issue of the relationship between ownership rights and administrative rights, and the issue of enterprise decision making rights. 3) The issue of invigorating S&T and preparing "reserve strengths" for technical progress in enterprises. 4) The issue of prices. 5) The issues of finance and taxation. 6) The issue of enterprise functions. 7) The issue of allocation systems, including the issue of income differentials among regions and industries and the issue of "brain inversion". 8) The issue of import and export policies. 9) The Issue of employment and labor insurance. 10) The issue of assessment of enterprises by administrative departments. Obviously, these problems will be very hard to resolve and we must give them comprehensive consideration and do things carefully. However, if we discuss them forever without reaching a conclusion and never make a decision, the problems will continue to accumulate and become even harder to resolve.

VI. Proposed Countermeasures for Promoting Technical Progress in Enterprises

Technical progress in enterprises involves complex systems engineering, so it requires unremitting efforts by enterprises as well as the creation of an appropriate economic environment by the state to provide guidance, encouragement, and support in policies. On the basis of China's present economic and social conditions, we propose the following countermeasures.

A. Continue to intensify reform and strengthen the motive force and vitality of enterprise technical progress

The key to technical progress in enterprises is whether or not enterprises have the motive force and vitality for technical progress. The fountainhead of this motive force and vitality is market competition and the administrative management system of enterprises. In a highly centralized planned management system, enterprise investments depend on the state, guaranteed sales are implemented for products, and people's minds lack a consciousness of a commodity economy. Technical progress in enterprises has insufficient motive force and vitality, and expanded reproduction often focuses on extension while neglecting intension. Since reform and opening up, the situation has changed some but not in a fundamental way. As China's economy shifts onto the track of the planned commodity economy, enterprises will face pressure from market competition, so they may treat technical progress as their own duty. Moreover, after enterprises truly become commodity producers and managers who make their own administrative decisions and are responsible for their profits and losses and have self-restraint, they will have inherent vitality. Thus, continued intensification of reform is a fundamental measure for promoting technical progress in enterprises.

B. Strengthen effective investments in enterprise technical progress

Technical progress is inseparable from capital inputs. Thus, trying in every way possible to strengthen effective investments in the area of technical progress in enterprises is an indispensable measure for promoting technical progress. In the current situation of relative difficulties in state finances and slipping economic results in enterprises, how can we strengthen effective investments? We propose: 1) The state should strictly control the scale of investments in fixed assets, reduce investments in new construction and expansion projects, and use more capital on technical upgrading and on developing new products and new technologies. Given the large scale of the machine-building industry and its still relatively low technical levels, the focus of work at present should be on strengthening integrated reorganization and on technical upgrading, optimizing industrial structures, enterprise structures, and product mixes, expanding specialized cooperation, improving the performance and quality of products, and striving to develop new product varieties. New construction and expansion projects must be strictly controlled. 2) We should reinforce inspection and feasibility research for technical upgrading projects and select projects that conform to the state's industrial policies and are truly urgently needed, and which require relatively small investments and produce rather good results. Overcome

the phenomenon of competing for projects and competing for investments and avoid the appearance of the problems of new construction and expansion done in the name of technical upgrading.

For those projects where there has been thorough debate and a decision has been made to establish the project, administrative departments and the relevant enterprises should use contractual arrangements to clarify duties and rights and implement effective supervision to ensure investment results. 3) The various funds set aside by enterprises in accordance with stipulations should be strictly implemented as special funds for special purposes. Examples include development funds from enterprise retained profits, depreciation funds, and major overhaul funds, which should be used for technical upgrading and equipment replacement. Technology development expenditures should be included in their entirety in new product and new technology development funds. Patent fees for S&T achievements developed by enterprises themselves and income from technical patents for enterprise R&D organizations should be used for technology development, and so on. The state can authorize banks to supervise the utilization situation for this capital.

C. Clarify the responsible management departments and their duties for technical progress in enterprises

Technical upgrading and technology development are two important measures in enterprise technical progress. For many years planning departments have managed technical upgrading while S&T departments have managed technology. It was easy for the two to become detached, which was not beneficial for technical progress in enterprises. To truly increase the technical progress content in technical upgrading, we propose clarifying that ministry S&T departments and S&T departments in local agencies and bureaus are the responsible management departments for technical progress in enterprises. Besides fulfilling their duties, they should meet with planning departments to inspect enterprise technical upgrading and technical item import plans. After the plans are established, planning departments still supervise their implementation and S&T departments should be involved in examining and accepting the start of construction.

D. Gradually establish an enterprise technology development system, reinforce cooperation between enterprises and scientific research academies and institutes

Large and medium-sized enterprises are representative of technical levels and they are responsible for important technology development tasks. Experience in China and foreign countries has confirmed the total necessity of establishing and perfecting an enterprise technology development system. In the long-term perspective, large and medium-sized enterprises should become the main force in technology development. However, this process must be gradual and most enterprises at present do not have such conditions. Thus, one realistic, effective, and capital-saving route is fully fostering the role of existing scientific research academies and institutes and reinforcing integration and cooperation between enterprises and academies and institutes. This is an issue that should receive attention in reform of the S&T system at the present time. For the past few years, there has been an intensifying slant in large and medium-sized enterprises and scientific research academies and institutes toward self-perfection, efforts to form their own structures, and detachment of scientific research from production, and attention should be given to reversing this trend. Administrative departments at all levels should adopt measures to organize large and medium-sized enterprises and scientific research academies and institutes so that they jointly assume responsibility for technology importing, attacks on key S&T problems, and major technology development tasks, use existing capital to the fullest extent, and foster the advantages of each. One method is to make enterprises the main force, use tasks and funds as a bond, have industrialization and commercialization as objectives, use bid solicitation and competition, and adopt policies of encouragement to attract all big S&T armies into the main battles of service to economic construction and promoting technical progress in enterprises.

E. Perfect enterprise technology management systems, formulate enterprise technical progress programs

Enterprise management is an important aspect of technical progress in the broader sense and an important measure for promoting technical progress in enterprises, so the two wheels of technology and management should turn together. The content of enterprise management is extremely broad, but at the present time it is particularly important that we establish and perfect a management system for technical progress, for example, adhering to the "Provisional Stipulations Concerning the Duties of Senior Engineers in Large and Medium-Sized Enterprises in the Machine-Building and Electronics Industry" to clarify the duties of senior engineers, establish and perfect a technology management system led by senior engineers, ensure that senior engineers perform their duties, and adhere to the technology responsibility system.

Formulation of enterprise technical progress programs is a primary link in reinforcing technology management. Enterprises should use the state's industrial policies and technology policies as a basis, start with reality, carry out overall designs and formulate programs and annual plans for the strategic objectives and implementation steps for technical progress, organically integrate improvement of product quality, increased product varieties, reduced energy consumption, technical upgrading, technology importing, digesting, and absorbing, technology development, and employee training, propose concrete and clear requirements, integrate present work with long-term development objectives, implement them in a planned and step- by-step manner, and expend arduous efforts for a substantial period of time to improve the quality of enterprise technology another

step. Enterprise technical progress plans should be coordinated with industry and regional technology development programs and submitted to higher-level administrative departments for examination.

F. Continue to perfect policy measures regarding technical progress in enterprises

Under the conditions of the planned commodity economy, technical progress in enterprises still requires macro guidance, coordination, and organization by the state, but the main role of government is not to rely on directive-type plans to intervene in the actual activities of enterprises. Instead, it is to make full use of economic levers and the role of policy guidance to influence enterprise behavior. Thus, as reform intensifies, the state should continue to perfect policies related to technical progress in enterprises. For example, it should focus on formulating technical equipment policies, guide technical upgrading and equipment replacement in enterprises, and strictly limit the production of obsolete and backward equipment. Technical upgrading should involve the adoption of advanced and appropriate technical equipment and not permit the spread of old technology, old equipment, and old products nor permit the use of capital on low-level expanded production capabilities. It should encourage the adoption of technically mature new equipment and new technology that can guarantee "quality, product varieties, and results". Continue to perfect existing economic policies, reduce the tax burden on enterprises, increase depreciation rates as appropriate, allow enterprises to retain over-quota profits earned by relying on technical progress in enterprises, ensure compensation for tangible and intangible damage to fixed assets, and increase the enthusiasm of enterprises for technical progress. Spur enterprises to continually develop new products that are competitive in the market and adopt advanced modes of production.

Footnote

[1] This research was a soft science research project assigned by the Ministry of Machine-Building and Electronics Industry.

Making Marine Resources Exploitation a National Policy

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[Article by Yang Jinsen [2799 6855 2773]: "Make Marine Development A Strategic Cause"]

[Text] In the recent history of the world, whoever controlled trade on the seas controlled the wealth of the world. In the modern era, using the seas for developing international economic trade and for developing and utilizing marine resources still has major economic and strategic significance. China has the largest population of any country in the world and we should make development and utilization of the seas a strategic cause. For this reason, we should adopt a variety of measures to improve our ability to develop and utilize the seas, gradually establish modernized marine food resource, mineral resource, energy resource, and water resource base areas, use the Earth's seas as a passageway to develop international economic relationships, and make China a maritime power in reality.

I. The Necessity and Possibility of Making Marine Development and Utilization a Strategic Issue

The Chinese continent adjoins the seas of the western margin of the northwest Pacific Ocean: the Bohai Sea, Yellow Sea, East China Sea, and South China Sea. Our continental coastline runs for more than 18,000 kilometers and the marine regions listed above cover a total area of more than 4.73 million square kilometers, so we have favorable conditions for entering the seas to develop and utilize marine resources. China's coast has a total of about 50 million mu in beaches and barren land awaiting reclamation and utilization. There are a total of more than 200 bays suitable for harbor construction along the coast that could be used for expanding harbor construction to promote the development of maritime shipping. China's offshore fishing grounds cover an area of about 2.8 million square kilometers and contain more than 1,500 fish species, including over 70 important fish species of economic importance. They are also rich in prawns, crabs, and algae resources. In addition, the 1.3 million-plus square kilometer continental shelf region contains abundant oil and gas resources. At the same time, we could also enter the high seas to develop and utilize biological resources and enter the international sea floor region to explore for and develop mineral resources.

China has the world's largest population but relatively inadequate natural resources, so we must make marine development a strategic undertaking. First, China has a population of 1.1 billion, of which more than 40 percent lives in coastal provinces (municipalities and autonomous regions), so we must continually expand development and utilization of marine food products. China's aquaculture products averaged 10 kg per capita in 1990, which is lower than the world average level. The per capita average for aquaculture products in the nations of Southeast Asia is 30 to 40 kg. For China to attain this level, our aquatic products would have to be increased from 12 million tons to 40 million tons, which cannot be achieved within the short term. It will require long-term efforts and continual expansion of marine and freshwater development and utilization.

The energy resource shortage is a prominent restricting factor in China's economic development. At present, 20 percent of China's industrial production capacity is still lying idle because of the energy shortage. About 50 percent of our rural area does not have electricity and there is a 20 percent shortage of household energy resource supplies calculated at the minimum standard. Thus, we urgently need to develop all types of energy resource industries, which includes development of oil

and gas resources on the continental shelf and utilization of tidal, wave, temperature differential, and other marine energy resources.

Shortages of water resources are a global problem and China is no exception. Projections indicate that by the year 2000, China will have a water shortage of about 70 billion tons during moderately dry years. The regions with the greatest shortages will be concentrated in the north, northeast, and northwest China regions as well in mountainous areas and coastal regions of south China. Because our coastal regions are economically developed and consume large amounts of water, the water resource shortage will become increasingly acute. Diverting large amounts of seawater for use as industrial cooling water and desalination of seawater are one of the main ways to solve the shortage of water resources in coastal areas.

Because coastal areas have implemented a strategy of developing the export- oriented economy, there must be large scale imports and exports of raw materials and products on the seas and a substantial increase in the maritime shipping cargo volume is inevitable. This requires us to accelerate the pace of harbor construction and actively develop maritime shipping fleets. To do otherwise will restrict implementation of our coastal region development strategy and development of our entire national economy.

II. Establish a Strategic Consciousness and Concept of Marine Development and Utilization

Compared to the continent, the seas are a virgin land that has just begun being developed. With the development of S&T, mankind will continually discover new developable marine resources, marine industries will continue to grow, the regions of development will continually expand, and the existence and development of mankind will depend to an ever greater degree on the seas. For this reason, we must establish a consciousness of the seas and strengthen our strategic concept of the seas.

First is the concept of marine territory. After the establishment of territorial waters, exclusive economic zones, and the continental shelf system, many countries developed, utilized, and managed these marine regions as their national territories, thereby forming the concept of marine territory. The world's oceans and seas cover an area of about 360 million square kilometers, including about 130 million square kilometers of regions that have been placed under the jurisdiction of coastal nations in the form of 200 nautical mile exclusive economic zones, equal to about 35.8 percent of the total sea area. Coastal nations enjoy decision making rights over the exploration and development of natural resources on their continental shelf and in exclusive economic zones. It is entirely in this sense that the United States, Japan, and many other countries are treating these regions as marine territory. China has not yet formally announced the establishment of the 200 nautical exclusive economic zones nor have we formally demarcated the outer boundaries of our continental shelf. As a result, there is no way at present to calculate precisely our marine area. However, China's position is that, based on the relevant principles of international law, China could ultimately demarcate 2 to 3 million square kilometers as its jurisdictional marine area. This is a territorial region with substantial development potential.

Second is the concept of resource treasurehouses. The seas contain five categories of resources: organisms, minerals, chemical elements in seawater, spatial resources, and marine energy. There are very large reserves of all these categories of resources and they have enormous development potential. For example, there are about 200 million tons of organic resources available for development and utilization, more than 100 billion tons of extractable petroleum reserves, and more than 300 million tons of polymetallic nodule resources in the international sea floor region. The seas as resource treasurehouses have major real development value as well as huge potential development value and are the site for mankind to obtain reserve natural resources.

Third is the concept of global passageways. Nearly all the various relationships in modern socioeconomic development are global in nature. The higher the level of industrial development, the broader the scope of relationships between raw materials production areas and products. Many regions are separated by the oceans and must use the sea as a passageway. At present the world has more than 3.6 billion tons of cargo that must be shipped by sea. China has about 100 million tons of foreign cargo each year that must be shipped by sea. If problems appear in maritime passage like the blockade of Iraq's outbound passageways during the Gulf War, an entire national economy could suffer major losses. For this reason, the more an economy is developed the more concern it must have for outlets to the sea and outbound passageways.

III. Strategic Objectives and Deployments for Marine Development

In 1989, China had about 4 million people employed in marine industries and the value of output in primary marine industries was 24.5 billion yuan. Starting with China's national conditions, national strengths, and social requirements and the actual levels of marine development at the present time, the key region for China's marine development prior to the year 2000 is still the coastal zone and offshore seas, and the key marine industries are ocean fishery, communication and transportation, and development of the oil and gas resources of the continental shelf. The gross value of output of primary marine industries may be doubled on the existing foundation. After entering the 21st Century, we should focus on developing marine new-tech and high-tech industry. The focus in this regard is exploration and development of marine oil and gas resources, marine agriculture and animal husbandry over a large

area of the sea, comprehensive development and utilization of seawater, underwater marine engineering, and so on. At the same time, we will develop marine energy utilization, deep-sea mining, marine recreation, and so on, improve the status of marine development in the national economy, and gradually reduce our lag behind advanced world levels.

Regarding the strategic deployments for the marine industry, we can classify them according to technical standards and time sequences into traditional industry, emerging industry, and future industry. For example, the marine industry that formed prior to the 1960's without relying on new technology is traditional industry, which includes marine fishing, maritime transportation, and the seawater salt making industry. Industry formed after the 1960's to the year 2000 that depends on emerging technology is emerging industry, and includes marine petroleum development, seawater breeding, and the marine tourism and recreation industries. The marine resources that cannot be developed until the 21st Century can form several future marine industries, including marine energy utilization, deep-sea mining, comprehensive seawater utilization, and so on.

Table 1. Marine Industry Configuration

Traditional industry	Maturely developed industry	Maritime transportation industry
		Shipbuilding industry
		Sea floor coal mining industry
	Slowly developing industry	Fishing industry
		Sea salt industry
Emerging industry	Currently developing industry	Offshore petroleum industry
		Near-shore sand quarrying industry
		Seawater breeding
		Salinization industry
		Marine tourism, water sports
	Industry in initial stages of development	Seawater desalination
		Marine service industry
		Shallow sea fish raising industry
Future industry	Industries that may appear in the short term	Deep- sea mining (manganese nodules)
		Deep-sea oil extraction industry
		Tidal power generation industry
		Seawater comprehensive utilization industry
		Floating plants and cities
	Industries that may appear in the long term	Extraction of uranium from seawater
		Wave energy and temperature differential power generation
		Sea floor industry base areas
		Sea floor cities

Mankind's development and utilization of the seas has developed gradually from the coasts to the deep seas and the oceans. The regional configuration of marine development can be divided into three zones: the coastal zone, the 200 nautical mile exclusive economic zones and the continental shelf, and the open seas and international sea floor. The coastal zone is the boundary area between land and the sea. In China at present, this usually refers to shallow water areas within the 15 meter isobath, coastal beaches and barren land, and part of the coastal land. China's coastal zone covers an area of about 350,000 square kilometers and has a variety of natural resources. It is suited to the development of farmland reclamation, aquatic breeding, the salt industry, harbor construction, and the reed and other industries. The exclusive economic zone and continental shelf are offshore marine regions over which China can have jurisdiction. The focus there is on developing marine fishing, marine agriculture and animal husbandry, and oil and gas resource development. The high seas have abundant organic resources and all countries can fish there. The international sea floor has polymetallic nodules and other mineral resources and is the common property of all of mankind. As the most populous country in the world, China should also enjoy the benefits of developing the resources of the open seas and international sea floor.

Status of Marine Resources Exploitation, Modernization of Marine Technology in China

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[Article by Zhu Guangwen [2612 0342 2429]: "Marine Resource Development and Modernization of China's Marine Technology"]

[Text]

I. Marine Resources and Environment

The seas are closely interrelated with mankind's existence and development. The world's seas cover an area equal to 70.8 percent of the Earth and the volume of seawater is about 1.37 billion cubic kilometers. The seas contain abundant organic, mineral, chemical, motive power, and seawater resources and the development of offshore oil and gas resources has created enormous wealth for certain coastal nations. Projections by experts indicate that by the year 2000 the gross value of output of the marine economy will reach $3 trillion, accounting for 15 to 17 percent of the gross value of output of the world's economy. China's coast has concentrations of primary industrial cities and the maritime passageways of international trade, and an urban and rural population of about 400 million. The prosperity and decline of our coastal economy approximates China's overall national economy. China has 18,000 kilometers of coastline and the marine area within the scope of China's administrative jurisdiction is equivalent to one-third of China's land area. The gross value of output of primary marine industries in China in 1989 was 24.5 billion tons. With the intensive development of reform and opening up, the coastal economy and marine economy will play increasingly important roles in China's national economic construction.

Another influence of the seas on mankind is the environment. The continents on which we live are surrounded by the oceans and the cooling and warming of the oceans and variations in them control changes in the global climate. Overall, the seas provide an excellent environment and abundant resources for mankind's existence and development but the seas do not always bring benefits to mankind. Huge waves, storm tides, tsunamis, ice freeze-ups, tropical storms, red tides, and other marine disasters also pose enormous threats to human activity on the seas, to coastal industrial and agricultural production, and to the lives and property of coastal people.

To develop and utilize marine resources, monitor and protect the marine environment, and reduce losses from marine disasters, we must develop marine science and technology. The marine S&T levels of a country are an indicator of that country's ability to develop marine resources, protect the marine environment, and reduce marine disasters.

II. Marine Technology Is the Pillar for Developing Marine Resources and Protecting the Marine Environment

Overcoming the protective screen of seawater will be much more difficult that overcoming the atmosphere. It can be said without any exaggeration whatsoever that entering the sea will be harder than ascending to the sky. The development of marine resources will require a cost far greater than developing resources on the land. Drilling in the sea, for example, costs about three times more than drilling on land and involves even greater risks. Marine technology levels are an important indicator of the S&T levels, industrial levels, and economic strengths of coastal nations.

Basically, marine technology is divided into the two main categories of marine observation technology and marine engineering technology. Marine observation technology includes the use of satellites, airplanes, ships, platforms, and submersibles to conduct spatial, planar, and underwater three-dimensional observations. Marine engineering technology was developed to prevent and reduce marine disasters for the development of marine resources and utilization of marine space. The development of sea floor oil and gas resources has promoted the development of underwater exploratory drilling, extraction, storage, and platform structure technology, the development of seawater chemical resources has promoted the development of marine chemical industrial technology, and underwater engineering has promoted the development of diving, submersible, and underwater operations machinery. The development of modern marine technology has brought fundamental changes to the old concepts of traditional salt drying, fishing, and sailing in marine resource development and utilization. Experts predict that the world will enter a new era of marine development during the 21st Century, so modernization of marine technology should be an urgent task for coastal nations.

III. Modernization of China's Marine Technology

For the past several decades, and in particular since the 1980's, China has made substantial progress in marine technology and we are now striving to catch up with advanced world levels in several important areas to gradually achieve modernization of China's marine technology.

A. Marine remote sensing technology

Marine remote sensing technology includes space (satellite) remote sensing and aerial (aircraft) remote sensing. Satellites are the instrument carriers for space remote sensing. They make observations of the sea from outside the Earth and make large-dimension, global marine observations. Airplanes are the carriers for aerial remote sensing. They have a much smaller field of view than satellite remote sensing but their flights are flexible and the images they obtain have higher clarity and resolution. Aerial remote sensing is also a technical foundation and auxiliary measure for space remote sensing. It plays

an important role in observation of the marine and atmospheric processes within typhoons, in making surveys of dynamic changes of coastal zones and river mouths, and in other areas. The United States launched the first marine satellite [Seasat 1] in 1978, which was an indication that marine observation technology had entered the new era of space remote sensing. It can observe sea surface wind speeds and wind directions, waves, sea surface temperatures, icebergs, sea surface topography and oceanic water levels with a measurement precision of 8 cm. With improvement in radar altimeters, the measurement precision could reach 3 cm. Seasat has greatly increased the efficiency of marine observations. The sea surface temperature field of the entire globe could be plotted using the data obtained by about 3 months of flight by Seasat. In contrast, it would have taken nearly 50 years to obtain similar results using traditional methods. China has done a great deal of work in the area of using satellite information resources from foreign countries and satellite information resources from Chinese satellites for marine research, including coastal and island resource surveys, harbor site selection, iceberg and sea surface water temperature observations and forecasts, fishing grounds analysis, pollution monitoring, research on coastal geomorphology, seawater color, and other areas. In the area of aerial remote sensing, we completed aerial remote sensing fishing ground surface temperature monitoring and velocity report systems during the Seventh 5-Year Plan, which produced significant economic benefits.

B. Marine information surface buoy and underwater buoy technology

Using surface and underwater buoys for marine hydrometeorological and water quality monitoring is an extremely important technical measure in modern marine observations. A characteristic of anchored series of information buoys is that they are capable of long-term continuous monitoring at fixed sites of the marine hydrometeorological environment in all types of weather and at all times. The buoys are usually disc-shaped with a maximum diameter of about 12 meters and a minimum of 3 meters, and there are also buoys shaped like ships. Surface buoys have battery power supplies and microcomputer controlled data collection, processing, storage, and transmission. Most of them use satellite communications and positioning. The buoys can operate continuously for more than one-half year. There are now about 120 information buoys in the world. China included the development of 10 Chinese-made information buoys in the State Plan To Attack Key S&T Problems during the Seventh 5-Year Plan. A representative one is the F2SH information buoy. It can monitor wind, air pressure, air temperature, water temperature, waves, and currents and uses a hard disk as external memory. It has shortwave, ultra-short wave, and Argos satellite communications capabilities and can operate in place for more than one-half year. The effective data collection rate is greater than 80 percent. China's information buoy technology has now attained advanced international levels of the 1980's.

Drifting buoys are buoys that "float with the waves" at the sea surface or at a certain depth layer. They are usually used to monitor large-dimension marine currents, water temperature, surface winds, and air pressure and temperature and are also used to track the drifting of oil leaks in the sea. The characteristics of drifting buoys are that they can "float across the oceans" until their energy is exhausted. China does not have any drifting buoys in use at the present time, as they are in the laboratory development stage.

Underwater buoys are a type of modern marine observation technology anchored beneath the water that can do continuous long-term self-recording at fixed locations and that can be released to float upward at fixed times when instructed to do so and be recovered. They are used mainly for monitoring currents and water quality. The maximum depth at which they are deployed at present is 8,000 meters. They can operate continuously in place for up to 1 year. China began developing underwater buoy technology in the late 1970's and we began using an underwater buoy system in 1986 to conduct experiments on deep-sea current measurements and deep-sea marine organism adhesion and corrosion. It operated at a fixed site underwater for 105 days and produced China's first marine current information at a depth of about 1,000 meters in China's South China Sea. Deep-sea current measurement underwater buoy systems were used for a joint Sino-Japanese black tide survey in 1990. On the second survey flight all of the two sets of systems deployed were recovered. The systems operated on-site for 21 days. Shallow-sea underwater buoy systems have also been used for a marine environment survey in the seas off the western part of the mouth of the Zhu Jiang [Pearl River]. They gathered information on the sea current cross-sectional distribution when typhoons crossed our border and provided direct services to offshore petroleum company projects in the western part. China's underwater buoy technology has now entered the application stage and the technology has attained the levels of similar international technology during the mid-1980's.

C. Coastal observation technology

Coastal observation refers to the use of coasts, islands, and platform stations for making observations of marine hydrometeorological parameters. Advanced marine nations in foreign countries have already achieved automation of coastal observations using a variety of automated monitoring systems. The most representative one is the Global Sea Surface Change Monitoring System that the United States began building in 1984. They plan to establish over 200 automated monitoring stations along coasts on a global scale that will be integrated with precision positioning and geodesic survey systems to compute absolute changes in the sea surface.

China made extremely important advances with its marine platform hydrometeorological automated observation technology during the Seventh 5-Year Plan. We built three automated observation systems on Yongshu Jiao in the

Nansha Islands [Fiery Cross Reef in the Spratly Islands], at Lusi Marine Station in Jiangsu, and Xiaomai Island Marine Station in Shandong. Representative of them was the automated observation system at Nansha Marine Observation Station. It is capable of automatic monitoring of wind, air pressure, air temperature, humidity, water temperature, salinity, tides, waves, and other parameters and manual observation parameters could be keyed in manually. After the data collected were processed, they were sent back at fixed times to a coast station via high frequency communications and the ARGOS satellite communications system. It is now providing the United Nations Educational, Scientific, and Cultural Organization with monthly average tide level information at the station's location and it participates in global sea surface network observations. This station is representative of the automation and modernization levels of China's coastal observations.

D. Underwater sounding

Underwater sounding mainly involves the use of hydroacoustic technology, underwater television and photographic technology, and submersible and robot technology. Hydroacoustic technology plays an extremely important role in marine geological and geomorphological surveys, searching for sunken ships and obstructions, surveying for underwater polymetallic nodules and incrustations, sounding for schools of fish, measuring the cross-sectional distribution of currents, surface winds and precipitation, and other areas. The maximum depth of measurement using hydroacoustic technology in foreign countries at present is 11,000 meters at a vertical measurement precision of 10 to 29 meters. At a ship speed of 10 knots, measurements covering 1,300 square kilometers in marine areas with water depths of 4,000 meters to plot the geomorphology of the sea floor can be completed in 1 day. Marine acoustic layer refraction technology can be used to plot the cross-sectional distribution of currents, seawater temperatures, heat flux, and eddy currents in regions of the ocean covering 1,000 X 1,000 square kilometers. China has made considerable progress in the area of hydroacoustic sounding technology over the past several years. The MBSP multiband acoustic sounding system based on a theoretical design by China's Marine Technology Institute and manufactured by the (Leisheng) Corporation in the United States has been used successfully in oceanic surveys for manganese nodules. It has a sounding capability of 12,000 meters and a maximum operating water depth of 6,000 meters in sounding for manganese nodules and incrustations. It can also do soundings of shallow strata cross-sections within 50 meters of the sea floor.

E. Underwater engineering technology

Underwater engineering technology developed along with the development of marine resources, especially on the basis of the needs of oil and gas resource development and underwater fishing and rescues. It mainly includes underwater and submersible technology, underwater operations technology, oil and gas drilling and extraction, platform design and manufacturing technology, deep- sea bottom polymetallic ore extraction technology, underwater equipment dynamic positioning technology, and so on. The laboratory saturation diving depth in foreign countries has reached 686 meters and on-site experiments in the sea have reached diving depths of 520 meters. Diving depths in animal experiments have reached 1,500 meters. Atmospheric pressure diving using diving suits has now attained diving depths of 300 to 450 meters. China's saturation diving technology lags substantially behind foreign countries. We used Chinese-made equipment in 1987 to conduct 300 meter helium-nitrogen-oxygen saturation diving simulation experiments but we still do not have the capability of 200 meter saturation diving operations. The maximum depth in atmospheric pressure diving, however, can reach 300 meters at a life-sustaining time of 72 hours. In the area of submersible technology, there were 184 manned submersibles in the world at the end of 1988 as well as a total of 985 unmanned remote control (cable and wireless) submersibles. Most have diving depths in the 6,000 meter grade. Japan's Marine S&T Center has been developing a 10,000 meter grade deep submersible. The development trend in foreign countries is to replace manned submersibles with unmanned submersibles and to expand the operating range of unmanned submersibles. China completed development of its first deep diving rescue ship in June 1986 which has a diving depth of 600 meters. It can use a butt joint skirt to lower a rod and transfer accident personnel at atmospheric pressure and it can open its hatch within a range of 200 meters for wet rescue of six personnel. In addition, Shanghai Jiaotong University and the Chinese Academy of Sciences have cooperated to develop China's first unmanned remote sensing submersible HRO-1, which is called the Hairen-1. Its maximum operating depth is 200 meters and it has underwater television, mechanical hands, and positioning sonar. They have also begun development of an unmanned wireless submersible. In summary, China is now squeezing into the ranks of the world's advanced nations in underwater technology in the area of submersible technology.

Petroleum at the bottom of the seas now accounts for about one-fourth of the total amount of petroleum that has been discovered in the world so far. As a result, nearly one-half of all the exploration investments made by petroleum corporations in the advanced marine nations in the past several years has been used for marine petroleum exploration to develop marine petroleum exploration, extraction, logging, and oil and gas storage and transportation technology. Current petroleum production is concentrated in shallow sea regions at depths of less than 100 meters, but there are a few oil wells in deeper sea areas at about 200 meters. Moreover, about 90 percent of marine petroleum exploration is concentrated in continental shelf areas at depths of less than 200 meters. The data show, however, that petroleum resources in deep water regions have one and one-half

times more reserves than oceanic coastal zones at depths of less than 300 meters. The deepest deepwater exploratory well at present is 1,350 meters. The primary marine technology related to underwater drilling and oil extraction is the platform manufacturing technology used in drilling and production and drilling acoustic positioning technology. The existing shallow-sea petroleum platforms are mainly steel structure conduit framework-type fixed platforms. The petroleum platforms used in deeper waters are floating platforms like the tension leg-type platform. The lower part of the platform is a series of flexible anchoring systems fixed to the sea floor, so it is not a rigid structure. A new advance in sea floor oil extraction technology is research on a fully-submerged type petroleum platform and oil storage structure in which all of the equipment is placed on the sea floor with only pipelines running to the surface to transport oil. This arrangement is suitable for oil extraction in deep-sea regions. China's marine oil and gas industry and technology levels have developed very quickly and we have used cooperation with foreign countries and importing and digestion of advanced technology so that overall we have attained international levels of the 1970's in primary technological realms. We have attained 1980's levels in some areas. For marine engineering technology, we have learned how to design, manufacture, and install marine platforms and conduit frameworks and they have passed the grade acceptance inspections by the American Boat Classification Society (ABS). More than 90 percent of our well logging technology has attained advanced international levels. The relatively rapid development of China's marine petroleum S&T and our advanced equipment has now enabled China to assume responsibility for more than 50 percent of marine operations with an income of several $100 million.

Review of S&T Funding System Reform

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[Article by Cheng Zhendeng [4453 2182 4098], Deng Tianzuo [6772 1131 0146], Wang Guanchang [3769 7070 2490], and Zhu Haixiong [2612 3189 7160]: "A Summary of Reform of the Fund Allocation System in Technology Development-Type Scientific Research Units"]

[Text] Reform of the S&T fund allocation system undertaken in accordance with the "CPC Central Committee Decision Concerning Reform of the S&T System" and "Provisional State Council Stipulations Concerning Management of Science and Technology Allocations" is an important aspect of reform of the S&T system. For the past 5 years, implementation of management by categories for expenditures in scientific research organizations and the application of various economic levers for adjustment and control have effectively promoted integration of S&T with the economy. A new type of S&T operational mechanism that is adapted to the needs of developing a planned commodity economy is now gradually taking shape. Qualitative progress has now been made in reform of the allocation system and it is now developing in a healthy and smooth manner.

I. Progress in Reform of the S&T Allocation System

1. Management by categories is being carried out in scientific research units. Based on the requirements in the CPC Central Committee decision concerning reform of the S&T system, the State Planning Commission began engaging in work to promote reform of institutional funding in 1986 on a national scale. Institutional funding of civilian scientific research organizations was transferred from unified plans in financial departments to science and technology commissions at various levels for "implementation of management by categories over expenditures in accordance with the characteristics of activities in different categories of science and technology departments". This refers to the implementation of a technology contract system for technology development-type scientific research units, implementation of an expenditure contractual responsibility system for social public benefit-type scientific research units, implementation of an integrated institutional allocation, special item allocation, and fund system for basic research-type scientific research units, and other new operational mechanisms.

So far, 6,767 scientific research organizations at the county level and above with 680,000 employees and workers in 60 ministries and commissions of the central government and 42 local provinces and municipalities with about 3.3 billion yuan in scientific activity expenditures (calculated on the basis of 1990) have been brought into the track of new allocation operations.

The situation for expenditures by category at the central government level is 37 percent in the development category, 21 percent in the basic research category, and 42 percent in the social public benefit category. For provincial and municipal scientific research units, the figures are 33 percent in the development category, 2.5 percent multi-system units, and 64.5 percent contractual responsibility units. They have completed "categorization of scientific research units, which is foundational work for reform of the S&T system".

2. Institutional funding for technology development-type scientific research units has been reduced each year. The goal is not to reduce S&T investments in this category of scientific research units, but is instead to change the operational mode for expenditures and to establish new S&T operational mechanisms that are adapted to the needs for development of the planned commodity economy and that benefit S&T progress. Moreover, administrative and economic measures are applied for active promotion of the integration of S&T with the economy. At the same time, we have paid attention to the application of interest drive mechanisms and policy guidance to encourage them to use active orientation toward economic construction and toward

society and, while contributing to economic development, to earn incomes to compensate for insufficient institutional funds. Moreover, two-thirds of the reduce institutional funds are returned to the S&T management departments of these scientific research units for use as subsidies in their development of industrial technology work and key state scientific research projects. One-third will be used by the State Science and Technology Commission as an S&T commissioned loan fund and S&T loan interest deduction fund, and economic contract arrangements will still be used to support S&T work.

For the past 5 years, the State Science and Technology Commission has adhered to the work principle of "firm directions, stable steps, steering a careful course, differential treatment, comprehensive starts, and stable reform" and has actively created policies and an environment that is conducive to promoting reform of the allocation system. Integrated financial administration, banking, taxation, and other departments have formulated over 20 matching policies dealing with finance, taxation, interest, loans, and materials that have effectively promoted intensification and development in every phase of reform of the allocation system.

In 1991, in accordance with the decision of the CPC Central Committee concerning reform of the S&T system, all reductions were completed in the reduced allocations of institutional funds to technology development-type scientific research units in departments of the central government and the goal of reducing allocations as part of reform of the S&T allocation system was fully achieved in this category of units. With the exception of certain frontier provinces and autonomous regions where it will take another 1 or 2 years to achieve, local areas have achieved the reduction of allocations in 80 of percent units and for 75 percent of expenditures. These are indications that major historical changes have occurred in China's S&T allocation arrangements and S&T operational mechanisms.

II. Important Accomplishments in Reform of the S&T Allocation System and Their Profound Significance.

Although reform of the S&T allocation system and reduced allocations of institutional funds to technology development-type scientific research units have touched upon only about 35 percent of our scientific research academies and institutes, they have played an enormous role in spurring all S&T circles to take the initiative to serve economic construction, promoting integration of S&T with the economy, and spurring the transformation and formation of the concept of orienting toward the market and orienting toward the economy on the part of all S&T personnel. They have also had a profound impact on accelerating the development of S&T and the economy. This is manifested in:

1. New S&T operational mechanisms that meet the needs of developing our planned commodity economy and that are conducive to S&T progress have been established in a preliminary fashion. Reductions in allocations of institutional funds to technology development-type scientific research units has strengthened their ability and vitality in orienting toward society and orienting toward economic construction. Their funding sources have shifted from simple financial allocations to earning income from society via multiple channels. Incomes from S&T have risen each year. The S&T funds earned through multiple channels from society in China's scientific research units, referring to their gross incomes, reached 5.55 billion yuan, which is 1.7 times the financial allocations at all levels. This includes 2.36 billion yuan in gross income for development-type units under the central government, equivalent to the amount prior to reform, which is also 9.5 times the base figure for institutional allocations in 1985. Their net income was 422 million yuan, equivalent to 2.7 times the amount of the reduction in institutional allocations (reductions in allocations of institutional funds from 1986 to 1990 totalled 157 million yuan). Reform has caused the potential funding source advantages of scientific research units to burst forth like a volcano with many times as much energy as before reform to participate in society's S&T and economic activities. This has resulted in historical changes in the structure of the proportions of income earned by orienting toward society and orienting toward the economy compared to financial allocations in China's scientific research units. It is a reflection of their transition from being of a purely academic type toward being a scientific research and administration type. It also passed the test of dealing with the problems of inflation and a period of economic readjustment and gave them powerful strengths for participation in economic activities. The development of S&T work is now consciously and unconsciously moving toward the track of the planned commodity economy.

2. Reform has spurred the integration of S&T and the economy in terms of mechanisms. It has supported and promoted the undertaking and coordinated development of S&T work at the three levels of the main battlefields in economic construction, high-tech tracking and research, and basic research. Now, more than 60 percent of the S&T personnel in scientific research units at the central government level and 70 to 80 in local areas have entered the main battlefields in service to economic construction. At the same time, 20 to 30 percent of S&T personnel have been maintained at the leading edge of basic research and tracking of world high-tech development. The strategic idea proposed by the CPC Central Committee of readjusting the deployment of S&T forces in depth has been achieved in a preliminary manner.

3. Spurred by the larger trend of reform, many technology development-type scientific research units have explored many good arrangements for entering and developing the economy during the process of fighting for existence and development. Many technology development-type scientific research units are now shifting directions from a purely scientific research type to integration of scientific research, production, and administration. Some 1,055 S&T-type enterprises have been

established, more than 10,000 integrated scientific research and production bodies have appeared, and many integrated companies that integrate scientific research, design, production, construction, and services as well as a large number of industrial S&T development centers have been formed. These good arrangements that were formed through practice in reform are displaying ever more apparent flourishing vitality in orienting toward the economy and in promoting rapid development of S&T and the economy.

4. Reform has spurred integration of S&T and finance. There has been a significant increase in the scale of S&T loans over the past 5 years. The scale of S&T loans in China grew from 20 million yuan in 1984 to 3 billion yuan in 1991 and they are gradually becoming one of the three main pillars of S&T investments and an important capital source for activities to commercialize S&T achievements. The opening up of S&T loan channels and continual expansions in their scale have effectively promoted the startup and implementation of the "Spark", "Torch", "Achievements Extension", and other S&T development plans and accelerated the conversion of S&T achievements into forces of production.

5. Reform has brought profound changes to the concepts of S&T personnel. It will inevitably have a profound impact on the development of China's S&T activities in the future and on S&T progress. This impact will become increasingly apparent as time passes.

Practice in reform over the past 5 years has proven that the direction of reform of the S&T allocation system carried out in accordance with the CPC Central Committee decision concerning reform of the S&T system is correct, that the pace is steady, that its development is healthy, and that the results are apparent. This confirms the correctness of the CPC Central Committee decision on reform of the S&T system. Of even more profound significance is that it is the first instance in the history of S&T development in China in which a preliminary structure has been formed that integrates and mutually adapts the operational mechanisms of China's technology development-type scientific research units with the planned economy and market regulation, and it has adapted it to the overall principles of China's economic reform and adapted it to the laws of S&T and economic development. This will inevitably have a profound impact on the rapid development of China's S&T and economy.

However, the requirements set forth in the CPC Central Committee decision on reform of the S&T system have not been fully achieved. The accomplishments made so far in reform of the S&T fund allocation system are only the first step taken in continued intensification of reform of the S&T system and reform of the economic system. Continued exploration of ways to closely integrate S&T progress with economic development is still proceeding very slowly and there is still a great deal of arduous effort that we will have to make.

During the Eighth 5-Year Plan and the 1990's, we should continue to have one "center" and two "base points" as our guiding ideology for comprehensive adherence to the CPC Central Committee decision on reform of the S&T system. We must continue to work on exploring and promoting the establishment of "vigorous and vital new mechanisms conducive to S&T progress and economic development". "On the basis of the requirements of developing a socialist planned commodity economy, explore routes and arrangements for integration of planned management with market regulation in S&T work and promote further integration of S&T with the economy." Promote more rapid and more effective development of S&T and the economy.

III. Situations Facing Reform of the S&T System and Countermeasures

In today's world, S&T are expanding into and permeating the economic realm with an unprecedented vitality and speed. As the first force of production, S&T are now becoming the decisive factor in the economic development of any country and region. Competition among nations in the last half of the 20th Century has been increasingly embodied as competition of overall national strengths and competition of S&T advantages.

In the 21st Century, S&T and economic competition will become even more intense. We must adopt truly effective measures and strive to move forward with S&T and move forward with economic development to achieve substantial development of the social forces of production. The key to realizing the superiority of the socialist system lies in more rapid development of the social forces of production than under capitalism. Liberating the social forces of production to the maximum extent is not just an S&T issue. It is also an economic issue. All relevant departments should do real work within the scope of their own professions to support the development of S&T and create excellent policies and an environment for liberating S&T forces of production.

Using S&T to invigorate a nation requires invigoration of S&T first. Invigorating S&T requires first investments and second the creation of policies and an environment conducive to S&T progress and conducive to the integrated and coordinated development of S&T and the economy. The CPC Central Committee decision concerning reform of the S&T system and reform of the S&T allocation system now being implemented have injected enormous vitality and motive force into scientific research organizations and made them release enormous amounts of energy in orienting toward society and orienting toward the economy. In promoting social and economic development, their ability and strength in adapting to the planned commodity economy have been reinforced. Since reform, we have made a transition in S&T investments from single financial allocations to multilevel and multichannel earnings. S&T as the first force of production are now playing an unprecedented role.

However, the insufficient investments in S&T that accumulated over a long period of history were not changed during the Seventh 5-Year Plan. Although there have been some increases in the technical income of scientific research units and organizations over the past several years and insufficient S&T investments and institutional funds have been alleviated to a certain degree, this is far from capable of meeting the requirements of S&T institutional development. Moreover, the average yearly rate of increase in S&T investments from state revenues during the Seventh 5-Year Plan was only 5.9 percent, which was 5.69 percent lower than the 11.69 percent average yearly rate of increase in state revenue income over the same period. The average annual ratio between S&T investments from state revenues and state revenue income was 9.7 percent during the Sixth 5-Year Plan and 4.6 percent in the Seventh 5-Year Plan, which was the lowest in more than 20 years. At the present rate of growth in S&T investments from state revenues, allocations of S&T institutional funds will only be able to sustain the basic wages of S&T personnel by the year 2000.

China has more than 1,000 large academies and institutes under the jurisdiction of departments of the central government and most of them were built during the 1950's and 1960's. They have made enormous contributions to developing New China's S&T activities. There are still many problems in the development of these academies and institutes, however, the main one being that the existing instruments, equipment, buildings, motive power, living services, and other public facilities have been in service for several decades and the phenomenon of severe aging is quite common. S&T financial budgets show that 32 percent of the instruments and equipment that have been in use for more than 20 years are in urgent need of discarding and replacement and that replacing instruments and equipment has become essential. However, there have been no capital channels and accounts in finances for instrument renewal and upgrading in scientific research units for the past several years. The area of dangerous buildings has grown, not decreased, rising from 700,000 square meters in 1989 to 980,000 meters in 1990. There has been a substantial reduction in capital construction investments in scientific research units and scientific research capital construction has been reduced each year because of non-productive construction for a long period.

Solving these problems by having scientific research units rely completely on orienting toward society and orienting toward the economy and using technical income is not possible for S&T circles in China and would be difficult even for scientific research organizations in economically developed countries. Moreover, enterprise S&T progress mechanisms in China at present are not strong and S&T investments are low. Technical upgrading and technical progress have not yet shifted to reliance on S&T forces within China, which also presents difficulties for reform and development in scientific research units. Further integration of S&T with the economy is restricted, which means that the role of S&T as the first force of production is far from being fully fostered.

For this reason, if we want to achieve the second strategic objective for development of our national economy and society proposed by the CPC Central Committee and lay a solid foundation for achieving the third strategic objective, we must "truly shift economic construction onto the track of relying on S&T progress and improving the quality of laborers". We must liberate S&T forces of production to the maximum possible extent. One urgent task is to strengthen unified coordination and leadership of the CPC Central Committee over reform of the S&T system, reform of the economic system, and reform of the political system, to create an excellent social atmosphere that respects knowledge and respects skilled personnel, and to adopt realistic and effective measures and use administrative, market mechanism, and legislative measures to increase investments in S&T by society as a whole. Create policies and an environment conducive to sustained, stable, and coordinated development of S&T and the economy. For this purpose, I propose that:

1. Financial administrations at all levels should establish unified S&T investment accounts and ensure increases in S&T investments from financial administrations that are higher than increases in financial incomes and increases in our GNP. Make arrangements for a specific proportion of expenditures each year for focused use on replacing and upgrading instruments and equipment and reinforce the development reserve strengths for S&T work. Treat scientific research capital construction as productive construction projects, set aside a specific proportion each year for inclusion in departmental capital construction plans, and make preferential arrangements.

2. Increase enterprise investments in S&T as practical. Regular enterprises should set aside more than 1 percent of their total sales and high-tech enterprises should set aside more than 5 percent of their total sales for use in industry and enterprise S&T development. Allow enterprises to set aside a certain proportion of their income tax for investment in S&T to provide the conditions for enterprise development to be able to focus on extensive development and truly shift onto the track of relying on S&T progress and improving the quality of laborers and take the path of intensive development. Shift the concern of enterprises from expanding product output value to concern for improving product quality and enterprise economic results. Many enterprise technical progress and technical equipment replacement and upgrading shift from a focus on relying on imports from foreign countries to combining imports with relying on their own efforts in order to shift onto the track of relying main on China's S&T forces.

3. We must continually increase the scale of S&T allocations, actively explore and promote the establishment of risk investment mechanisms and systems adapted to

China's national conditions, truly solve the capital support problems for converting S&T achievements into forces of production and "developing high-tech and achieving industrialization", and accelerate the conversion of S&T achievements into real forces of production.

4. Strengthen research on S&T investments, reform investments in S&T. Be concerned with using investments in S&T and using regulation and control via various policy and economic levers to guide S&T to develop toward the required directions.

5. Continue to maintain continued stability and leave unchanged all matching policies that benefit S&T reform and development. In addition, we should further strengthen close integration of S&T departments with planning, financial, taxation, banking, industry and commerce, foreign trade, customs, and other departments, continually study the state of S&T system reform and development, and continue to create more favorable policies and an environment for promoting reform and development of the S&T system, for promoting the formation of high S&T industry, and for moving technology development-type scientific research units into domestic and world markets so that they can exist and grow in reform and open competition.

Management of Research Institutes' Funding Studied

92FE0359H Beijing KEYAN GUANLI [SCIENCE RESEARCH MANAGEMENT] in Chinese No 1, Jan 92 pp 33-36, 57

[Article by Li Feng [2621 6912] of the Chinese Academy of Sciences Hefei Intelligent Machinery Institute: "Practice and Discussion of Research Institute Fund Management Work"]

[Text] Abstract: This article uses practice in the Hefei Intelligent Machinery Institute to analyze the characteristics of research institute fund management work, proposes nine areas for doing good subsequent management of fund projects, and offers some opinions concerning improvement of fund management.

Key term: fund management

Since the establishment of the National Natural Science Foundation in 1986, implementation of the science fund system has played a major role in promoting the development of basic research in China, stabilizing S&T staffs, training skilled S&T personnel, and other areas.

Regarding the entire process of fund management, if it can be said that the National Foundation played a key role in building a "stage" for fund projects in its initial management, then whether or not basic level management units can "perform" this "opera" well in subsequent management for subsidized projects is of decisive importance. The reason is that now the National Foundation depends on an expert system for management and must concentrate its forces on processing applications and checking on their examination and approval. Management after projects are approved and assigned depends mainly on basic levels and there is basically a "relationship of forms" between the Foundation and basic levels. In this situation, the quality of basic level management will undoubtedly have direct effects on the level and quality of the completion of subsidized projects. As for the management work in basic level units, management by research institutes (especially technology application-type research institutes), institutions of higher education, and other departments have different characteristics and methods. This article seeks to integrate with practice in fund management in the Hefei Intelligent Machinery Institute to discuss some experiences and ideas.

I. Some Characteristics of Research Institute Fund Management Work

With the intensive implementation of reform of the S&T system over the past several years, there have been reductions to varying degrees in the institutional funds of research institutes that have led to research institutes making comprehensive readjustments in scientific research directions, personnel allocations, and other areas to adapt to the requirements of the new situation. On the one hand, they want to participate in state attacks on key problems, "863" high technology, and other major research projects while on the other hand they also want to orient toward society and orient toward the market, organize crack forces to carry out technological product development, accelerate the commercialization of scientific research achievements, and continually earn income to develop themselves. There is rather less attention to fund research projects that involve low investment strengths, few expenditures, long schedules, and heavy burdens (this is substantially different from the situation in institutions of higher education). This type of phenomenon has unavoidable negative effects on fund management work.

Through several years of management practice, we feel that while these problems do exist objectively, because each research institute has its own unique advantages in disciplines, equipment, and other areas, making full use of these advantages, fostering strong points and avoiding weak points, organically integrating fund project management with management of other projects, and making unified arrangements and rational deployments can ensure smooth completion of fund projects and play a definite role in promoting research on projects in other categories and in the scientific research activities of the institute. In all, our fund management work has three main characteristics:

A. Taking time in coming to a decision, selecting projects that have extension and expansion possibilities or a applications background

In applications for fund projects, we are concerned with avoiding "short-term behavior" in scientific research activities, fully integrating with our institute's discipline

advantages, and selecting projects with "benevolent accumulation" possibilities. In this way, when a fund project being studied concludes, we can use our own achievements as a foundation for entering scientific research activities at an even higher level. The "benevolent accumulation" in this type of scientific research activities on the one hand consolidates and develops our specialized advantages in our own discipline and on the other hand it naturally trains specialized personnel in a continual process. This characteristic was fully embodied in the scientific research activities of our Robot Transducer Topic Group. In 1986 they assumed responsibility for the fund project "Six-Dimensional Wrist Force Transducer Matrix System Experimental Research". After 2 years of unremitting effort, they not only completed their task splendidly but also used this as a basis for successfully applying for an "863" high-tech project on "Robot Six-Dimensional Wrist Force Transducer Research" and achieved their original idea. Because a fund achievement laid a solid foundation for this project, they smoothly completed their task at the end of 1990, attaining advanced international levels and creating "three firsts in China", and generated several additional achievements. They also produced a "foreign Ph.D.", two students who studied abroad, and three M.A. students. In early 1991 this achievement was also given a "State 863 First Place Award in the Automation Field" by the State Science and Technology Commission. The comrades said with feeling: "If we had not had the 'seed' of this fund project to start with, we wouldn't have the 'big tree reaching to the sky' today".

B. Organically integrating fund project research with large project research

Because the Hefei Intelligent Machinery Institute is a technology-development type research institute in the Chinese Academy of Sciences [CAS], most of the fund projects we apply for are directional basic research with an applications background. This type of research often requires specific equipment conditions and it is usually hard to meet requirements by relying solely on fund expenditures. Establishing fund projects on a foundation of existing projects under study that have substantial conditions so that the two supplement each other with technology and both enjoy the use of resources plays a great role in promoting research on both sides. As a result, we have especially advocated assuming targeted responsibility for fund projects at the same time as large projects. Doing this has four prominent advantages:

1) Fund projects can become "appendages" of large projects and obtain "nourishment" from them to compensate for their shortcomings of limited funds and inability to purchase large equipment. 2) Because applications are made by targeting research requirements of large projects, achievements in fund project research are used to support research work on large projects, which gives an objective impetus to the need for completing fund projects with high quality and fast speed. 3) Project groups can receive subsidies from large projects and do not have to depend solely on fund post subsidies, so their work initiative is not affected. 4) The fund projects we assume responsibility for can be under guidance by older experts who allow younger people to work on them, which creates the conditions for accelerated training of talented personnel. In addition, fund projects are also a beneficial supplement to large projects in the area of expenditures.

For example, the Hefei Intelligent Machinery Institute assumed responsibility in 1986 for a state project to attack key problems during the Seventh 5-Year Plan, "A Universal Computer Real-Time Image Analysis Systems". During the research, comrades in the project group felt that they needed to study a new type of mathematical morphology theory to solve key algorithm problems in the project research. Thus, we applied to the National Foundation for a project on "Image Analysis Algorithms Based on Mathematical Morphology and Methods for Their Real-Time Implementation" and received approval. Relying on existing superior equipment conditions of a project to attack key problems, the work on this fund project was completed very quickly and it made optimum use of its own achievements to provide direct support to key research in a project to attack key problems and thereby splendidly completed the project to attack key problems, "Universal Real-Time Image Analysis" and it passed an inspection led jointly by the Ministry of Machine-Building and Electronics Industry and the CAS as well as examination and acceptance by the state, and it was honored as a achievement at "advanced modern international levels" by experts in the profession.

C. Perfected management organization, clear division of labor, relatively complete and rational management system

A unified management organization for centralized management of all the scientific research activities in the institute, the Science and Technology Office, was established in the Hefei Intelligent Machinery Institute, as was a management organization to provide technical facilities, financial services, reserve strengths, and other services. In addition, several management measures to guarantee normal operation of projects were formulated on the basis of actual requirements in research projects. This eliminated the fear of trouble in the rear on the part of scientific research personnel involved in fund project and other research, and it enabled them to put their minds at ease and participate in scientific research activities with full vigor.

II. Exploration of Subsequent Management Methods for Fund Projects

After several years of practice in fund management, we have gradually formed a set of management models that are rather well-suited to our own characteristics. On one hand, we have made an effort to improve the quality of reports to higher authorities and increase the hit rate. On the other hand, we have paid more attention to subsequent management of fund projects because expending

considerable effort on this work is essential for truly achieving "stabilizing staffs, promoting development, producing more achievements, and producing skilled personnel quickly" in fund projects. In addition, the quality of completion of subsidized projects can affect the reputation of additional applications. One effective way to do truly good subsequent management work for fund projects is to focus on the following areas.

A. Strive to improve the management levels and ideological quality of management personnel

Management of fund projects ultimately depends on the people who manage them. Without a staff that knows how to manage, is willing to manage, and is confident in managing, the work cannot be done well even if conditions are perfected and systems are made more complete. Our management personnel cannot simply sit in their offices assigning plans, listening to reports, and submitting forms. They cannot simply rely on experience but must also understand theory. In day-to-day work, we place three requirements on management personnel: 1) Self-study, meaning the study of management knowledge and the study of technical knowledge to have a good idea of the projects they manage. They cannot be S&T laymen. 2) They must go to basic levels to understand the situation and continually go out to discover and improve things. 3) They must be managers as well as service personnel who also serve S&T personnel with ardor and sincerity and help them solve problems.

B. Establish a management system with the Science and Technology Office as a management center that coordinates and supports all departments

Within the institute, we stipulated that the Science and Technology Office is responsible for relationships above and below, assigns scientific research plans, tracks project operation situations, coordinates management services of all departments, and so on. The institute's finance, facilities, administration, and other departments are responsible for management services regarding expenditures, equipment, materials, reserve strengths, and other areas. The institute's Academic Committee is responsible for evaluating scholarly levels at all phases in projects, offering revision proposals, providing scholarly advice, and so on. The clear division of labor among all departments has enabled project groups to find functional departments in a targeted way to help in solving problems they encounter that has objectively avoided various phenomena of "disputes over trifles".

C. Formulate truly feasible scientific research plans, dynamically manage the entire process of plan implementation

First, the Science and Technology Office coordinates project groups in jointly formulating scientific research plans that contain the annual content of scientific research, the quarterly content of scientific research, phased examination and acceptance indices, personnel and task assignments, arrangements for fund utilization, and other concrete aspects with clear duties. They are then handed down for implementation and then financial, facilities, and other departments are notified for implementation and management of matching plans.

During the plan implementation process, we always allow persons responsible for projects to occupy the central status in the research work. Persons responsible for the projects have the right to make rational allocations of funds within the plans and the right to organize personnel and allocate tasks. They also offer views on bonuses and benefits allocation programs. The Science and Technology Office often goes down to basic levels to gain an understanding of project progress and problems that exist, immediately readjust inappropriate aspects of plans, coordinate the resolution of problems that exist, hold timely problem discussion meetings as needed, and broadly seek opinions from the Academic Committee and related experts regarding solutions. In addition, the Hefei Intelligent Machinery Institute also holds an annual project report conference for comprehensive examination of the project progress situation.

D. Strictly implement a financial management system for fund projects

Within our institute, with the exception of stipulating the requisition of 5 percent from fund projects as administrative fees, we requisition no other fees of any kind and stipulate that surplus funds are continually provided to the project groups for their use.

E. Bring competitive mechanisms into fund project management

Our institute conducts scientific research competition activities among project groups that involve competition for quality of plan completion, surplus funds, theses, quality of forms submitted to higher levels, and so on, and we give awards at year's end to the winners.

F. Implement special "slanted" policies for fund projects

To create a relaxed and innovative environment for fund project research, we try to strengthen all types of service work. Because fund projects have limited funds and low incomes, this presents many difficulties for topic groups that only assume responsibility for fund projects that have definite effects on work initiative. To resolve these difficulties, we implemented several special preferential policies including: 1) Having the institute assume responsibility for all of the wages, labor services, and various types of welfare expenditures for fund project personnel. 2) Allocating in full the post subsidies provided by the National Foundation to project groups. 3) Giving preferential use to fund projects of the public equipment in the institute. 4) Setting up special accounts within the institute to establish project support funds that are used to support projects with insufficient funds. 5) Allowing projects that have not received their funds to borrow in advance from the institute. 6) Providing awards to fund projects with good completion conditions, and so on.

G. Concentrate forces, do good work in the fund project summarization and evaluation (or examination) phase

This phase is the key period for producing achievements. The Science and Technology Office on the one hand assists project groups in producing high quality theses and summary reports and on the other hand actively prepares for and organizes fact-based evaluation of project achievements by experts in similar fields and uses this as a foundation for arranging for continuing work by project groups.

H. Establish special project archives

To raise management levels and efficiency, we also compiled special software and used computers for project auxiliary management. The establishment of special project archives has also helped us submit all types of forms to higher authority on schedule and with good quality.

I. Establish "fund nurseries", pay attention to training reserve forces

To ensure successors for fund activities, discover talented personnel, and train skilled personnel, our institute set aside special accounts and used Foundation management methods to establish an "institute youth science fund". This provided a very good "drill ground" for all the young S&T personnel in the institute. In just 2 years, this tiny "fund nursery" had become a "shady grove" that applied for one state project to attack key problems during the Eighth 5-Year Plan and four National Foundation projects and open laboratory projects, and several of the items have entered technical development and application with extremely gratifying results.

III. Some Proposals for Perfecting Fund Management

We came to feel during actual management work that the National Foundation is still relatively weak concerning forces for subsequent management of projects and that there was considerable detachment between management in the initial and later periods. We believe that basic levels relying on basic levels is of course a good thing, but because the Foundation does not have a clear stipulation of requirements for subsequent management of projects and there are no corresponding reward or punishment measures for the quality of basic level unit management levels, this has led to several units forming a mistaken ideology that it is "easy to hand over accounts, with both the good and the bad being the same". A substantial portion of units are unable to submit management forms to higher levels in a timely manner and they do not pay enough attention to fund project management. This has affected the completion of fund projects and had definite effects on fostering the advantages of the fund system. We feel that the existence of these problems is not an inherent contradiction of the fund system and that by simply reinforcing survey research and further perfecting the management system, these defects can be overcome. For this reason, we propose:

1. Stronger training work for basic level management personnel and striving to create a group of qualified management personnel with modernized management skills and a strong sense of responsibility.

2. Stronger cooperative relationships with basic-level management units, reinforced management of forms submitted to higher levels by basic levels and evaluation and propaganda work regarding fund achievements, undertaking scheduled evaluation and selection work for superior basic level management units and advanced individuals and for project completion, and doing broad- based propaganda on good fund management experiences.

3. Stronger construction of regional networks, providing the necessary personnel and funding support, and dividing up some of the onerous work of the Foundation among regions for completion.

4. Trying to achieve computer network management as soon as possible. This can avoid excessive submission of forms to higher levels and help the Foundation collect information accurately, quickly, and dynamically. In particular, this would help in gaining an immediate grasp of the newest achievements in subsidized projects to accelerate the extension and application of achievements.

Survey of Chinese S&T Personnel's Job Contentment Released

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[Article by the ICSOPRU China National Research Group: "Research on Job Satisfaction of China's S&T Personnel"[1]]

[Text] [Abstract]

This article uses survey research by ICSOPRU to analyze the question of job satisfaction of China's S&T personnel and discusses favorable factors for motivating the work initiative of S&T personnel, the primary measures that affect initiative, and countermeasures.

Key terms: personnel research, satisfaction.

I. Research on Job Satisfaction

Job satisfaction concerns employee morale, which is the same as the question as employee initiative that we speak of. This is a topic that consistently has attracted the attention of behavioral scientists in the management field. Organizational behavior experts measure employee job satisfaction to study morale or initiative. Overall, research on job satisfaction can be divided into three main areas.

1. Discussion of the significance and content of work, factors that affect job satisfaction, and so on. For example, the organizational psychologist F. Herberg (1959) proposed the dual-factor theory that divides the factors affecting people's initiative into the two main categories of health factors and encouragement factors and suggested four concepts with different meanings, "satisfied", "not satisfied", "not dissatisfied", and "dissatisfied". When health factors are absent, people may become "dissatisfied". However, when health factors are present they can only eliminate people's "dissatisfaction" and maintain people's "non- dissatisfaction" but cannot attain "satisfaction". The existence of encouragement factors can make people feel "satisfied" but when there are no encouragement factors they may only be "not satisfied". Only with a foundation of satisfying health factors and continually providing encouragement factors can employees continually be made satisfied. This thesis provided a theoretical foundation of research on job satisfaction.

Research concerning the factors that affect job satisfaction has pointed out that the physical environment, social factors, and individual psychological factors are the three main factors that affect job satisfaction. Physical environment factors include whether or not there are excellent work site conditions and environment, whether or not facilities are complete, and so on. Social factors refer to attitudes toward the areas of work unit management and the degree of identification with and sense of belonging to the unit. Individual psychological factors include and employees' views and attitudes regarding the significance of his work, the category and style of leaders in superior departments, and so on, all of which are factors that affect job satisfaction.

2. Discussion of the relationship between job satisfaction and productivity. Research has shown a relatively complex relationship between job satisfaction and productivity. There is not a one-to-one relationship between them and high job satisfaction does not necessarily mean that productivity will be high. Neither does some dissatisfaction with one's job mean that productivity is certain to be low. For example, under high pressure, high productivity is associated with low satisfaction. In certain situations, high satisfaction is associated with low productivity. What factors of job satisfaction actually affect productivity? The general feeling is that these factors have especially important effects: 1) The work itself, including the significance of the work and the attitude of the employee toward their work, and whether or not their work puts their own skills to good use and achieves their aspirations. 2) A sense of identification with and belonging to the work unit, meaning whether or not they deeply love their work unit. 3) Opportunities for promotion and welfare treatment. 4) Relationships with colleagues in the work group. 5) Leadership modes, relationships to higher departments, etc.

3. The issue of methods for studying job satisfaction. Usually, the questionnaire survey method or quantitative table evaluation method are used. A scientific survey questionnaire or quantitative table is designed based on research objectives and in accordance with the compilation principles and procedures for questionnaires or quantitative tables. Scientific sampling techniques are used to conduct sample surveys and appropriate statistical methods (including multivariate statistical analysis) are used according to requirements to analyze the results and make interpretations. Foreign countries have now designed special questionnaires used to measure job satisfaction. An example is the famous Minnesota Satisfaction Questionnaire (MSQ) which contains 20 quantitative subtables having a total of 100 items. The CPM Leadership Behavior Evaluation Quantitative Table developed by the Chinese Academy of Sciences Psychology Institute's Industrial Psychology Research Office includes a job satisfaction quantitative table with eight subtables having 40 items. Discussions of this method are mainly done to adopt positive scientific research methods and develop scientific tools to make the measurement of job satisfaction more scientific.

Nearly all regular job satisfaction research is targeted at enterprise organizations and there is only extremely limited research on job satisfaction in scientific research organizations. The survey questionnaire used for ICSOPRU research contains some questions regarding the job satisfaction of S&T personnel. This article uses the survey results to analyze the job satisfaction of male and female S&T personnel in China in different areas. In certain areas, some comparisons are made with data from other countries. Comparisons are also made regarding the results for female S&T personnel at three levels—research group leaders, scientists and engineers, and technical personne—to determine what differences there are in job satisfaction for S&T personnel in different positions.

II. Satisfaction With One's Own Job

Research in organizational psychology has shown that job significance, job content, and whether or not this job gives a person opportunities to use their skills, achieve their ambitions, and so on play an extremely important role in encouraging people's work motivation. If the work is very significant and involves challenges and creativity, or if the content of the work is of personal interest and can foster one's skills, people will be satisfied with their jobs and feel a sense of satisfaction with their work.

Table 1 lists 10 items in the ICSOPRU survey questionnaire regarding job satisfaction. S&T personnel were allowed to make evaluations of the relevant items according to a five-level evaluation method, with 5 representing strong agreement (or high satisfaction), 4 representing agreement (or satisfaction), 3 representing normal (no statement of satisfaction or lack of satisfaction), 2 representing disagreement (or dissatisfaction), and 1 representing strong disagreement (or strong dissatisfaction).

Table 1. Assessment of Job Satisfaction By All Categories of S&T Personnel in China (N: 1,242 Males, 624 Females)

Job Satisfaction Item	Comparison of females and males			Comparison of three categories of female members			
	Female	Male	F	1	2	3	F
1. Strong guarantees of employment	4.33	4.41	4.143*	4.53	4.36	4.13	7. 636**
2. Very satisfied with social reputation of their occupation	3.93	3.92	0.054	4.02	3.99	3.73	4.913*
3. Not considering leaving this unit	3.92	3.76	9.076**	4.14	3.92	3.77	4.220*
4. Willing to assume more responsibility in unit	3.78	4.0	18.211**	3.96	3.87	3.48	9.227**
5. If I leave my unit, I expect no problems in finding similar or better employment opportunities	3.57	3.89	39.834**	3.69	3.63	3.34)	5.047*
6. Working in my unit gives me a feeling of individual accomplishment	3.44	3.67	22.143**	3.89	3.49	3.01	29.721**
7. Opportunities for promotion are determined by the quality of my work	3.05	3.17	3.985*	3.50	2.98	2.89	9.614**
8. Compared to other people, I feel satisfied by my own opportunities for promotion	2.77	2.84	1.328	3.13	2.76	2.54	8.561**
9. I feel that time pressures are too great	3.35	3.51	9.771**	3.71	3.35	3.11	12.571 **
10. I am willing to work a lot of overtime	3.58	3.78	14.142**	3.96	3.59	3.35	12 .929**

Notes: 5 is strong agreement, 4 is agreement, 3 is normal, 2 is disagreement, 1 is strong disagreement

F is a test of the significance of mean deviation. Significance is represented by P. *represents $P < 0.05$ and **represents $P < 0.01$, indicating that the deviation is extremely significant. $P >$ indicates there is no statistically significant deviation.

Items 1 and 2 are two items related to occupational satisfaction. The results of the scores show that both female and male S&T personnel gave evaluations of relative agreement for "employment guarantees" (4.41 for males and 4.33 for females). The also gave evaluations of agreement with "social reputation of occupation" (3.92 for males, 3.93 for females). This result shows that China's S&T personnel are relatively satisfied with their involvement in the scientific research profession.

Because all of the research organizations in the survey were under the system of ownership by the whole people, no unemployment problems exist for the S&T personnel, so their employment is guaranteed. S&T activities play a decisive role in the overall development of society and our national economy and the social reputation of the profession of scientific research work is self- evident. Although the phenomena of "brain inversion" in allocation and relatively low treatment for scientific research personnel exist now in China, because scientific research is a lofty profession and has a very high social reputation, S&T personnel still ardently love their activities and do their work cautiously and conscientiously and with silent devotion.

The results of items 1 and 2 show that although female S&T personnel at different levels all agree that they are satisfied with their occupations, there are significant or extremely significant differences among them. The scores for women research group leaders were higher than women scientists and engineers for both item 1 and item 2, and the latter group was higher than women technical personnel. This means that higher statuses have higher occupational satisfaction. The interesting thing is that this situation can be seen in all of the 10 items used to measure job satisfaction.

III. Satisfaction With the Work Unit

Liking one's work unit and not considering leaving this unit, as well as being willing to take on more responsibility for the unit, and so are represent a sense of identification or sense of belonging by employees for their work unit. This is an important aspect of assessing job satisfaction. The reason is that if employees lack a sense of identification with or sense of belonging to their work unit, they will not be able to actively strive in their work in this unit nor will they be able to produce achievements. Items 3, 4, and 5 in Table 1 measure the attitudes of S&T personnel toward their work unit. The table shows:

1. The responses of both male and female S&T personnel leaned toward agreement (nearly 4 points) in item 3, "not considering leaving this unit", and item 4, "willing to assume greater responsibility in the unit". This result shows that overall, China's S&T personnel have a rather strong sense of identification with and sense of belonging to their units.

2. Comparing men and women, female S&T personnel are even less "considering leaving their unit" than male S&T personnel. This was the only item among the 10 items for measurement of job satisfaction where women's scores were higher than men's scores. (women 3.92 > men 3.76). Moreover, the difference between them attained an extremely significant level statistically.

The results of item 4 show that male S&T personnel were more "willing to assume greater responsibility in their unit" than female S&T personnel (men 4.00 > women 3.78). The difference between them was also extremely significant.

3. The scores in item 5 show that the scores for men approximated agreement (3.89). This shows that if they considered leaving their present unit they would not find it difficult to find employment opportunities equal to or better than their present unit. Women members were generally slightly higher (3.57). If they thought of finding a new ideal unit, although they would not consider it difficult it would not be as easy as for men. This may be precisely one of the reasons that women S&T personnel give less consideration to leaving their present units that do male S&T personnel.

Overall, China's S&T personnel have a relatively strong sense of identification with and sense of belonging to their units and this is not due to difficulties in finding new employment opportunities. This point can be seen when comparing with the other six countries that participated in ICSOPRU research.

The data in Table 2 show that when comparing employment opportunities for S&T personnel in the seven countries, the percentages of Chinese male or female members who might think of leaving their present units and expect "almost no difficulties" in obtaining employment opportunities similar to or better than their current units are all far higher than the same genders in the six other countries. Moreover, the percentage of "very difficult" is far lower than for members of the same gender in the six other countries. The difference is even more significant compared to certain countries (like Sweden).

Table 2. Comparison of Obtaining Other Employment Opportunities for S&T Personnel in Seven Countries (percent)

Obtaining other similar or better employment opportunities	China		Austria		Belgium		Finland		Hungary		Poland		Sweden	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Almost no difficulty	67	54	57	50	36	28	47	35	36	26	55	46	18	11
Some difficulty	26	34	28	30	28	27	32	34	28	25	22	23	37	28
Great difficulty	7	12	15	20	36	45	21	31	36	49	23	31	45	61
Total number of people	1,242	624	1,080	256	557	243	498	249	289	470	339	542	285	92

"Not considering leaving this unit" and "if I leave my unit, I expect no difficulties in obtaining similar or better employment opportunities" are precisely two aspects of the same question. The resulting answers for these two questions precisely reflect the relatively strong sense of identification with and sense of belonging to their units on the part of China's S&T personnel. Even with other similar or better employment opportunities, they would not rashly leave their unit. This is a commendable aspect of China's S&T personnel as well as a foundation for research organizations to push forward with scientific research.

IV. Satisfaction With Feelings of Individual Accomplishment

Psychologist D. C. McLelland feels that accomplishments are one of people's basic requirements. The so-called "need for accomplishments" is an urgent hope and need for people to achieve success in their work or activities and a psychological requirement for making achievements. Satisfaction of this requirement is a feeling of accomplishment. A sense of accomplishment is a form of internal motivation that further encourages

people to pursue new achievements. A high need for accomplishments is a most fundamental characteristic of scientific workers. A person whose need for achievement is not high cannot become a good scientific worker. Whether or not a scientific research unit gives its members a sense of accomplishment in their work directly affects the enthusiasm of S&T personnel for scientific research work and the degree of their love for their unit.

An item for sense of individual accomplishment was designed in the ICSOPRU survey questionnaire. The scores for item 6 in Table 1, "working in my unit has given me a sense of individual accomplishment", show that the sense of accomplishment for China's S&T personnel falls with a middle range. The sense of accomplishment for male members is higher than for female members (3.67 for men > 3.44 for women). What factors actually affect the sense of accomplishment of S&T personnel? The results described previously show that we already know that China's S&T personnel are relatively satisfied with the work (occupation) of scientific research and that they have a rather strong sense of identification with and sense of belonging to their units, and are also relatively satisfied. Thus, these factors are not the primary factors that affect the sense of accomplishment of S&T personnel.

McLelland's research shows that one characteristic of those with a high need for achievement is that these people view individual accomplishments as more important than remuneration. They view remuneration as a indicator used to evaluate the accomplishments of themselves and other people. For S&T personnel, promotion in specialized job titles is an indicator used to evaluate their accomplishments. The reason is that job title grades represent society's recognition of the accomplishments or achievements a person has made. They are an indicator of scholarly levels and a symbol of honor and status. Thus, S&T personnel pay considerable attention to promotion in job titles. Whether this question is handled properly or not has a direct effect on the initiative of S&T personnel.

There were two items in the ICSOPRU survey questionnaire related to promotions. Table 1 shows that the evaluations for item 7, "opportunities for promotion depend on the quality of my work" (3.05 for women, 3.17 for men), and item 8, "compared to other people, I feel satisfied with my own opportunities for promotion" (2.77 for women, 2.84 for men), were both rather low for both men and women. They had the two lowest scores among the 10 items used to measure job satisfaction. This result shows that China's S&T personnel are not very satisfied with opportunities for promotion and assessment of job titles. The evaluations in these three items show that China's S&T personnel do have not a high sense of individual accomplishment. The question of promotion in job titles may be a major factor that affects the sense of accomplishment of China's S&T personnel.

V. Work Motivation

All types of human behavior are matched with specific motivations and people adopt certain types of behavior to satisfy all types of needs. "Work motivation" refers to the drive forces or factors that are matched with human work behavior. Research on the organizational psychology of scientific research shows that the most typical motivation of accomplished scientists is "self-trust" and "motivation for achievement" (D. C. Pelz and F. M. Andrews, 1966). These people believe in their ability to resolve scientific problems and strive in pursuit of scientific achievements. The extent of these efforts reflects the level of motivation. This shows that exploration of work motivation is extremely important for motivating the initiative of S&T personnel and doing good scientific research management work.

This section will not discuss the content of work motivation of S&T personnel and will only consider levels of work motivation for China's S&T personnel, which is to say that it will use certain items to measure the degree of work initiative of China's S&T personnel. In the ICSOPRU questionnaire, extent of feelings of time pressures (item 9) and willingness to work overtime (item 10) are used to measure levels of work motivation of S&T personnel.

Item 9 compares the degree of difference between the time pressures that S&T personnel actually feel in their work and the pressure that they feel are appropriate for themselves. If the actual pressures are far greater than the pressures appropriate for themselves, this shows that this person is dedicated to his scientific activities and immerses himself in his work but feels overall that not enough time is available and has a sense of urgency. The work motivation levels of this type of person are high, while the work motivation levels are low in the opposite case. The data show that China's S&T personnel have normal feelings of time pressures but there is a significant difference between male and female members (males 3.51 > females 3.35).

Scientific research work involves extremely arduous creative activity. Unlike other occupations, the work time of S&T personnel cannot be computed in terms of 8-hour periods. Research in the organizational psychology of scientific research shows that scientists who only work according to 8-hour schedules do not make good achievements. Thus, working overtime is an obvious characteristic of scientific workers. Moreover, this overtime work is entirely voluntary and they are not paid for overtime. What things are associated with scientific research personnel working this way? One important factor is a "spirit of dedication to science". This dedication is driven by "motivation for research". Thus, the evaluation of S&T personnel that they are willing to work a great deal of overtime can be one indicator to measure work motivation levels. The data for item 10 show that China's S&T personnel have a slightly higher than average willingness to work overtime. Males are higher than females (men 3.78 > women

3.58). Among female members, technical personnel are lowest (3.35), scientists and engineers are in the middle (3.59), and research group directors are highest (3.96). The mean for women research group leaders is even higher than the average level for male members. This result is a reflection of higher work motivation levels for higher statuses.

VI. Conclusion

A. Factors That Help Motivate the Initiative of China's S&T Personnel

This study shows that China's S&T personnel are relatively satisfied with the scientific research work they are engaged in and have a sense of pride in it. They have a rather strong sense of identification with and sense of belonging to the research units where they are located and love their units. They are willing to assume greater responsibility in their units. These favorable factors are the foundation for further motivation of the initiative of China's S&T personnel. With suitable policies, effective measures, and proper management, effectively encouraging their inherent motivation according to the characteristics of research work and dealing with the psychological characteristics of S&T personnel, the initiative of all S&T personnel can be motivated.

B. The relationship between status and job satisfaction

This study discovered from the evaluation results of job satisfaction by female S&T personnel at different levels that there is a definite relationship between status and job satisfaction, with higher statuses having higher job satisfaction. This is consistent with the usual results of research in enterprises. Generally speaking, the higher a person's status and duties, the higher will be their achievement and scholarly levels. Their accomplishments are more likely to receive recognition from higher departments, organizations, and society and they will have a higher sense of achievement and higher sense of honor. Thus, compared with the "job satisfaction" of people with lower statuses, they will have a higher degree of satisfaction. This shows that status and job titles are very important in motivating the work initiative of S&T personnel.

C. Primary factors affecting the work motivation of China's S&T personnel

Research in the organizational psychology of scientific research shows that the work motivation levels of accomplished scientists are very high. They are driven by the motivation to achieve and go all out in pursuing new successes, always feel that there is not enough time, and thus work overtime selflessly and dedicate themselves to the cause of scientific research. However, the results of our survey show that the work motivation of China's S&T personnel is only at an average level, so it would appear that their initiative is not being fully fostered. Behind these level motivation levels there are definitely several factors that affect the initiative of China's S&T personnel. This study discovered that among the 10 job satisfaction items, the two items receiving the lowest scores were both related to "opportunities for promotion". This shows that China's S&T personnel are not very satisfied with their opportunities for promotion.

Job titles represent the scholarly levels and scholarly status of S&T personnel and they are an organized recognition of their accomplishments. S&T personnel are extremely concerned about promotions to specialized technical job titles. For this reason, evaluating specialized job titles at appropriate times and in appropriate ways that correspond to their scholarly levels and work achievements to meet their need for accomplishments has special significance for S&T personnel. Satisfying the need for achievement is a type of "inherent encouragement" that is unlike money, materials, and other "external encouragements" in that it can provide long-term encouragement for their pursuit of new achievements, which is the work motivation for S&T personnel. Nevertheless, many problems still exist in the current situation in job title evaluation and recruitment in China's scientific research organizations and they cannot make people satisfied.

First, evaluation of job titles originally should have been a type of "encouragement factor" but they have become a "health factor" in many scientific research organizations. Evaluation of job titles in these units is not determined entirely by work quality but is instead done according to seniority and years of endurance. Moreover, administrative personnel in some departments are not involved in specialized work but they want scholarly job titles, which greatly reduces the scholarly value and social status of job titles. Their role in encouragement is also weakened as a result.

Second, job title evaluation in several research organizations lacks fairness and objectivity. In these units there are usually no objective and quantitative evaluation indices and the subjective component in evaluation standards is relatively large. Added to several improper working styles, the sacred "ruling" of job title evaluation may have an improper coloration of "favors" added because of "entering the back door" and "taking advantage of connections". This affects the fairness of the evaluations and may damage the initiative of S&T personnel.

D. Countermeasures

The factors that affect the initiative of S&T personnel are multidimensional and rather complex. Some are affected by the larger environment while others are induced by the smaller environment. Some are restricted by macro policies and others arise from improper micro management. Several factors in the macro environment cannot be controlled for a specific scientific research organization. However, working from the micro perspective to improve scientific research management levels and optimize the smaller environment to encourage the initiative of S&T personnel is entirely possible. As described previously, the most effective factor that

encourages S&T personnel to dedicate themselves to the cause of science is a motivation to achieve. If we create an excellent environment, provide an opportunity for S&T personnel to display their potential and skills, and give them social recognition and respect, we can greatly encourage their work motivation. For this reason, one of the problems that must be solved now is objective and fair evaluation of job titles for S&T personnel according to specific standards. China's S&T staff is a superior one. They love the motherland, show good sense, are faithful to their occupation, and are dedicated to the cause of science. We believe that if we can evaluate S&T personnel in an objective and fair manner, enable them to have a feeling of accomplishment and a feeling of honor, there will be substantial improvement in the work motivation of China's S&T personnel and their intelligence and skills will be fully fostered.

Footnote

[1] ICSOPRU is the abbreviation for the "International Comparison Study of Organization and Professionalism in Research Units" project directed by the United Nations Educational, Scientific, and Cultural Organization.

Study of Combustion Extinguishment of Solid Propellants by Liquid Injection

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[Article by Yin Jinqi [3009 6855 0366], Wu Xinping [0702 1800 1627], Zhang Baoqing [1728 1406 1987], Su Guangshou [5685 1684 1108], and Wang Kexiu [3769 0344 4423] of Northwestern Polytechnical University: "Study of Combustion Extinguishment of Solid Propellants by Liquid Injection"; project supported by NSFC, MS received 29 Apr 90]

[Text] **Abstract**

An analysis of the mechanism of combustion extinguishment of solid propellants by liquid injection is presented, and a physical model of combustion extinguishment by liquid injection is proposed. In addition, the results of an experimental study using double-base and polyurethane composite propellants are also presented. The results indicate that the liquid quantity requirement (LQR) for combustion extinguishment depends primarily on the energy characteristics of the propellant; specifically, the LQR increases significantly with increasing propellant energy. As the liquid injection pressure increases, the LQR decreases while the rate of extinguishment increases. The relationship between the LQR and the chamber pressure depends on the pressure exponent of the propellant n; when $n > 0$, the LQR increases with increasing chamber pressure, whereas when $n < 0$, the LQR decreases. The liquid properties also have a significant effect on the LQR; by changing the physical properties of the liquid using additives, the LQR can be greatly reduced.

I. Introduction

The use of liquid injection for combustion extinguishment of solid propellants is an important technique for providing multiple-restart capability in solid-propellant rocket engines. Its main advantages are: reliable extinguishment, minimal impact on engine design, no special requirement on propellant, and low contamination level on the combustion surface.[1-3] Implementing this technique requires a good understanding of the mechanism of combustion extinguishment by liquid injection and accurate determination of the liquid quantity requirement (LQR). Current studies show that extinguishment by liquid injection depends on the cooling effect of the liquid jet impinging on the combustion surface, particularly the vertical surface.[4] The critical LQR for composite propellants depends on the types of bonding agent and curing agent; the dependency becomes stronger with increasing combustion pressure.[5] The only theoretical model that describes the mechanism of combustion extinguishment by liquid injection and in particular, the heat-exchange mechanism between the liquid jet and the combustion surface is given in Ref. 6. The study results indicate that the heat exchange in the jet impingement distance-point [i.e., proximity] zone is almost an order of magnitude more intense than that in the expansion zone, and the rate of extinguishment in the distance-point zone is nearly two orders of magnitude higher. The model takes into consideration the effect of boiling heat transfer. However, in the heat flux calculations, a simple coefficient with correction factor is introduced to represent the effect of single-phase liquid convection; this is a departure from the results of current research in boiling heat transfer. Also, the model does not take into account the non-steady combustion process of the propellant. As a result, the relationships between the type of propellant, the combustion pressure, the liquid pressure and the LQR and rate of extinguishment are not reflected in this model. In this paper, a comprehensive analysis of the mechanism of liquid-injection combustion extinguishment is presented, and an improved physical model of combustion extinguishment in a solid propellant is proposed. The model is used as a guide for conducting experiments to study the effects of propellant types, injection conditions, combustion pressure and liquid properties on the combustion extinguishment process.

II. Mechanism of Combustion Extinguishment of Solid Propellants by Liquid Injection

According to the theory of combustion extinguishment of solid propellants,[7] when a combustion process is subject to external disturbances, such as pressure drop, reduction thermal radiation, etc., it switches from steady-state combustion to non-steady combustion. If the disturbances reach a critical level of rate and intensity, then the combustion becomes extinguished. The cooling effect on the combustion surface due to injection of liquid into the engine is an external disturbance to the combustion process. During the instant when the high-speed jet impinges on the combustion surface, different stages of heat transfer take place in the distance-point zone and the expansion zone: high-speed film boiling, transitional boiling, core boiling and liquid single-phase convection (see Figure 1). At the same time, a small quantity of liquid droplets are reflected and produce a cooling effect in a gaseous phase; the amount of liquid reflected depends on its adsorptivity. In the single-phase convection zone, the heat exchange between the combustion surface and the liquid can be neglected because the temperature difference is very small. Study has shown that in the case of a liquid jet impinging on a high-temperature surface, the boiling heat-transfer mechanism consists primarily of transitional boiling and film boiling; there is little evidence of core boiling on the liquid boiling curve. Therefore, transitional boiling and film boiling play an important role in the extinguishment process.

The heat flux of transitional boiling is determined by the liquid properties (surface tension, density, heat of vaporization) and the jet velocity.[4] In the film boiling zone, if the liquid temperature, the wall temperature and the liquid properties are given, then the heat flux is determined by the jet velocity.[10]

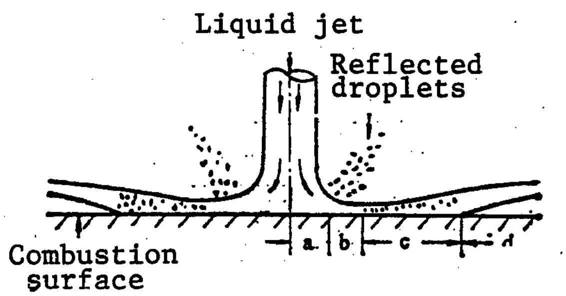


Figure 1. Heat Exchange Between the Jet and the Combustion Surface (the zones a, b, c, d are respectively controlled by single-phase convection, core boiling, transitional boiling and film boiling)

The jet velocity is determined by the injection pressure drop; as the pressure drop increases, the film boiling and transitional boiling heat flux increases, and the intensity and rate of disturbance to the combustion process increase accordingly; as a result, the rate of extinguishment accelerates, and the LQR for extinguishment is reduced. Because the liquid properties play an important role in boiling heat transfer, variations in liquid properties will also affect the LQR.

The heat absorbed by the jet from the combustion surface primarily comes from the solid-phase latent heat of the propellant, the condensed-phase reaction heat of the non-steady combustion process, and the thermal feedback between gas-phase and the combustion surface in the form of conduction, convection and radiation. Therefore, the energy characteristics (flame temperature and temperature of the combustion surface) and physical properties of the propellant have an important effect on the LQR for extinguishment. As the chamber pressure drops during the injection process, the non-steady combustion speed and the amount of heat released depend on the rate of pressure drop and the pressure exponent of the combustion speed.

The above analysis shows that the type of propellant, the injection conditions (jet pressure drop and velocity), the liquid properties (including additives) and the combustion pressure all have an important effect on the LQR and the rate of extinguishment. A systematic study of the effects of these factors is currently not available. For this reason, an experimental study of the combustion extinguishment process of solid propellants with regard to the above four factors has been conducted, and the results have been used to validate the proposed physical model.

III. Experimental Setup and Conditions of the Experiment

The experimental setup used in this study is shown in Figure 2. The operational procedure is as follows: the high-pressure nitrogen gas N_2 passes through the pressure-reduction valve and enters the low-pressure nitrogen tank and the liquid-fuel storage tank. By opening solenoid valve I, the nitrogen gas can enter the compression tank and drive the piston to pressurize the liquid; when the liquid pressure reaches a level equal to the sum of the fracture pressure of the aluminum membrane and the combustion chamber pressure, the membrane is fractured and the high-pressure liquid impinges vertically onto the combustion surface of the propellant. By opening solenoid valve II, the liquid from the storage tank can drive the piston back to its original position, and a certain quantity of liquid is injected into the compression tank for the next experiment. The liquid

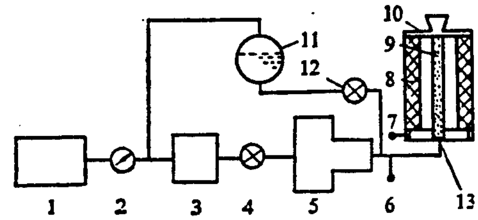


Figure 2. Simplified Diagram of the Experimental Setup

1. High-pressure nitrogen; 2. Pressure reduction valve; 3. Low-pressure gas bottle; 4. Solenoid valve I; 5. Compression tank; 6,7. Pressure sensors; 8. Charge; 9. Nozzle; 10. Engine; 11. Liquid-fuel storage tank; 12. Solenoid valve II; 13. Constant-pressure membrane

injection pressure and the combustion pressure are measured by two BPR-3 dynamic-pressure sensors.

The nitrogen pressure in the left side of the compression tank is 3.5 MPa, the compression ratio is 6, and the maximum flow rate is 3 kg/s. The amount of injected liquid can be adjusted by changing the thickness of the constant-pressure membrane to achieve different injection pressures. The propellant charge is packed inside a cylinder with covers on the sides and on both ends; its length is 75 mm and its inner and outer diameters are 60 mm and 112 mm respectively. After extinguishment, the charge can be dried and reused. The throat diameter of the jet nozzle can be chosen in the 5.5-7.5-mm range based on the initial combustion surface to achieve different combustion pressures.

In the experiment, we used pure water and a water solution containing 0.5 percent composite enhancing-agent (CE). The measured heat of vaporization of pure water is 40.6 KJ/mol and that of the water solution is 53.3 KJ/mol. In addition, the CE also increases the surface tension and the adhesion of the water solution. The propellants used in the study include a double-aromatic-magnesium-1 (DB) propellant (burning rate $r = 2.657\ P^{0.517}$ mm/s, where P is measured in MPa) and a polyurethane (PU) composite propellant, which has a negative pressure exponent ($r = 5.054\ P^{-0.382}$ mm/s). The constant-volume ignition heat of the double-base (DB) propellant is 3.6 KJ/g and that of the composite propellant is 5.2 KJ/g.

IV. Experimental Results

1. Extinguishment Process of Solid Propellant With Liquid Injection

The pressure-versus-time curve during the process of extinguishment of solid propellant via liquid injection is shown in Figure 3. After fracture of the membrane, the liquid pressure P_l drops abruptly and undergoes a period of oscillation; the liquid jet impinges on the combustion surface of the propellant at high speed. The pressure in the combustion chamber P_c decreases gradually at first, then drops quickly. This is consistent with results reported in Ref. 4. The rate of pressure drop is calculated based on the time required for the P_c to drop from its maximum value (point α) to 0.5 P_{cmax}. The LQR for extinguishment is the difference between the injected quantity of liquid and the amount of residual liquid after extinguishment.

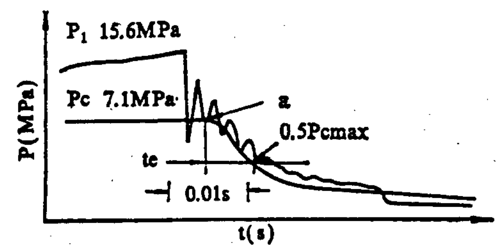


Figure 3. Pressure Versus Time During the Extinguishment Process

2. Liquid Quantity Requirement for Combustion Extinguishment

The variations of LQR per unit combustion area W_s (g/cm^2) with P_c (in MPa) and ΔP (which is the difference between the liquid injection pressure and the combustion chamber pressure (P_l-P_c)), are shown in Figures 4-7. For the DB propellant (Figures 4, 5), W_s increases with increasing P_c and decreases with increasing ΔP. For the PU propellant, W_s not only decreases with increasing ΔP, but also decreases with increasing P_c (Figures 6, 7). By adding 0.5 percent CE in the water, the LQR can be reduced by 35 percent and 25 percent respectively for the DB propellant and the PU propellant. It is also evident from Figures 4-7 that the effects of P_c and ΔP on W_s are essentially independent. By performing linear regression on the experimental data using the equation $F = aQ_f + bP_c + c\Delta P$ (Q_f is the constant-volume ignition heat of the propellant), we obtain the regression curve as shown in Figure 8; the error is within +/-6.5 percent.

It can be seen from Figure 8 that the absolute values of the rates of change of LQR with P_c and ΔP are larger for pure water than for the water solution with CE additives; in other words, the effect of liquid properties on the extinguishment process is enhanced by the CE additives. The absolute values of the rates of change of W_s with P_c and ΔP are smaller for the DB propellant than for the PU propellant; this implies that for the DB propellant, W_s is less sensitive to P_c and ΔP, which facilitates the extinguishment process. The coefficient a reflects the effect of the propellant energy. The data in Figure 8 show that for pure water, the values of a for the DB propellant and the PU propellant are respectively 0.1158 and 0.0986; for the water solution containing CE, the values of a are respectively 0.0758 and 0.0756, which represent a reduction of 34.5 percent and 21.5 percent compared with pure water. This is consistent with the reduction in LQR mentioned earlier. These results illustrate the important effects of liquid properties and propellant energy on LQR.

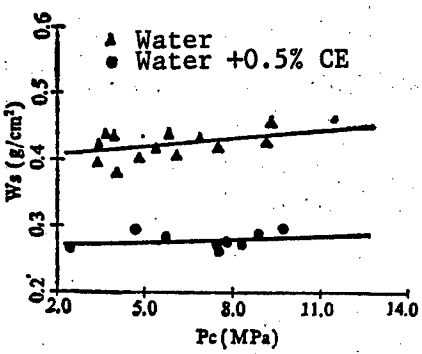


Figure 4. Variation of W_s With P_c for the DB Propellant

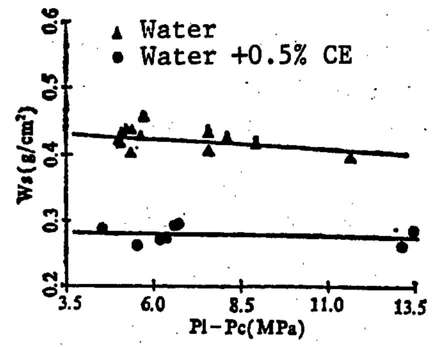


Figure 5. Variation of W_s With ΔP for the DB Propellant

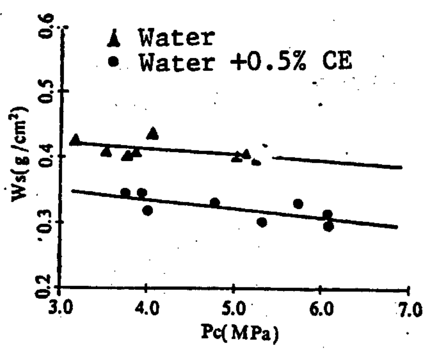


Figure 6. Variation of W_s With P_c for the PU Propellant

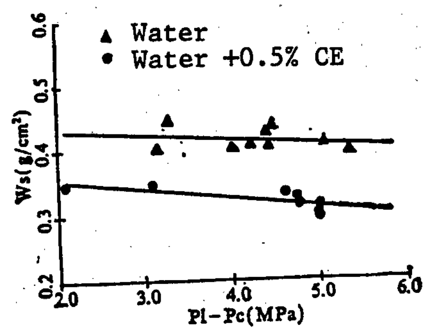
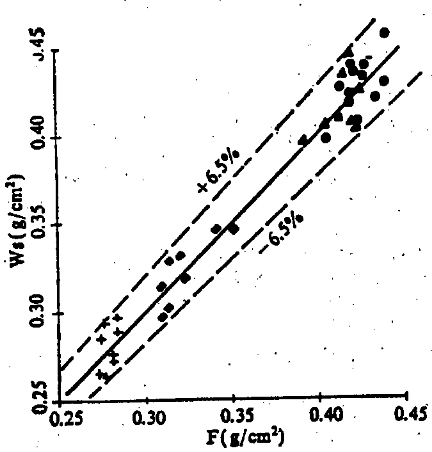


Figure 7. Variation of W_s With ΔP for the PU Propellant



	DB propellant		PU propellant	
	Water	Water +0.5%CE	Water	Water +0.5%CE
	●	+	▲	◆
a	0.1158	0.0758	0.0986	0.0756
b	3.658×10^{-3}	1.528×10^{-3}	-1.002×10^{-2}	-5.223×10^{-3}
c	-2.041×10^{-3}	-5.78×10^{-4}	-1.784×10^{-2}	-1.031×10^{-2}

Figure 8. Experimental Data and Regression Function of LQR ($F = aQ_f + bP_c + c\Delta P$)

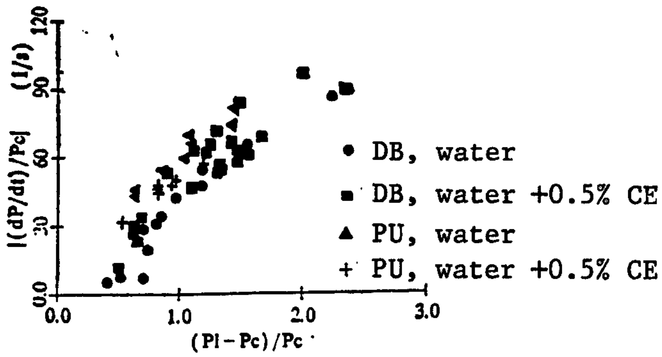


Figure 9. Variation of the Rate of Pressure Drop With $\Delta P/P_c$

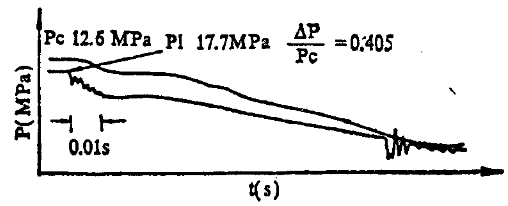


Figure 10. Slow Extinguishment Process (DB, water +0.5% CE)

3. Rate of Pressure Drop

The relationship between the rate of pressure drop $|dP_c/P_c dt|$ and $\Delta P/P_c$ during the extinguishment process with liquid injection is shown in Figure 9. As $\Delta P/P_c$ increases, the rate of pressure drop also increases. When the combustion pressure is very high and $\Delta P/P_c$ is small, the extinguishment process is slow (see Figure 10). Therefore, raising ΔP will speed up the extinguishment process.

V. Discussion

From the analysis results of the mechanism of liquid-injection combustion extinguishment and the experimental results presented above, one can deduce the primary factors affecting the extinguishment process of solid propellants.

1. Effect of Energy Characteristics of the Propellant, Pressure Exponent and Combustion Pressure

The energy characteristics of the propellant affect the temperatures of the gas and the combustion surface, as well as the thermal feedback between the gas phase and the combustion surface. An increase in energy will raise the amount of heat absorbed by the cooling jet, thereby increasing the LQR. The rate of energy release of the propellant is determined by the burning rate, which in turn depends on the pressure variations and the pressure exponent. Figure 11 shows the burning rates of the two propellants. While the burning rate of the PU propellant is much lower than that of the DB propellant, the LQRs for extinguishment are nearly the same (Figure 8); this is attributed to the fact that the energy of the PU propellant is approximately 44 percent higher than that of the DB propellant. Therefore, the LQR is primarily determined by the energy of the propellant. The data from Figure 8 also show that for given combustion pressure and injection pressure, F is proportional to 0.1 Q_f for pure water and F is proportional to 0.075 Q_f for the water solution containing CE. Hence, the LQR is proportional to the propellant energy.

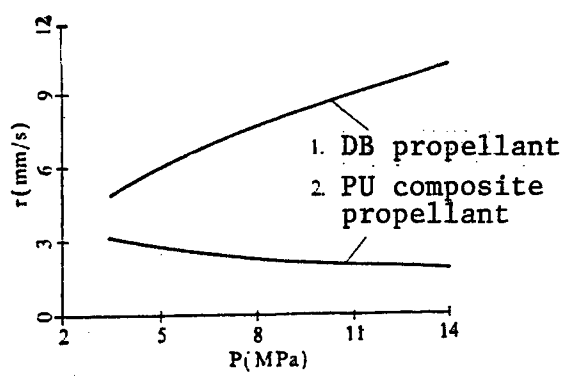


Figure 11. Burning Rates of Two Propellants

The variations of burning rate and propellant energy release rate with pressure also depend on the pressure exponent n of the propellant. When $n > 0$, the burning rate and the rate of heat release increase with increasing pressure, hence the LQR also increases; conversely, when $n < 0$, the LQR decreases with increasing pressure.

As the combustion pressure increases, the gas density inside the combustion chamber also increases; as a result, the penetration capability of the liquid jet is weakened, and the cooling effect is reduced. Therefore, the LQR for extinguishment increases.

2. Effect of Pressure Drop of the Injected Liquid

As the injection pressure drop increases, the jet velocity increases, and the heat flux associated with boiling heat exchange also increases; this results in a higher rate of

extinguishment and lower LQR. An increase in the injection pressure also enhances the penetration capability of the jet and therefore reduces the LQR.

3. Effect of Liquid Additives

In this experiment, 0.5 percent of CE is added to the water to raise the heat of vaporization by approximately 30 percent, and also to increase the surface tension and adhesion of the water solution. This reduces the amount of liquid evaporated for a given amount of heat absorbed, and therefore reduces the LQR. In addition, CE increases the heat flux in the boiling heat-exchange process, and reduces the amount of liquid droplets reflected from the combustion surface, which also reduces the LQR. Therefore, by selecting the proper additives, it is possible to achieve a significant reduction in LQR.

The experimental results and discussion presented above support the physical model for liquid-injection extinguishment of solid propellant proposed in this paper. This model takes into account the many factors which affect the liquid-injection extinguishment characteristics (LQR and rate of extinguishment) such as propellant type, injection conditions, liquid properties and combustion pressure.

VI. Conclusion

Based on the physical model for the mechanism of extinguishment and the experimental results, the following conclusions can be drawn:

(1) The reliable LQR of the propellant is primarily determined by the energy characteristics of the propellant; it increases linearly with the energy Q_f according to the formula F is proportional to aQ_f.

(2) As the pressure drop of the injected liquid increases, the LQR decreases whereas the rate of extinguishment increases.

(3) The variation of LQR with combustion pressure depends on the pressure exponent of the propellant; when $n > 0$, LQR increases with increasing P_c, when $n < 0$, it decreases with increasing P_c.

(4) By selecting proper additives to change the liquid properties (e.g., increasing the heat of vaporization, surface tension and adhesion), it is possible to significantly reduce the LQR. In this study, the LQR is reduced by 35 percent for the DB propellant and 25 percent for the PU propellant by adding 0.5 percent of CE to the water.

Additional work is required to improve the physical model proposed in this paper and to derive a mathematical model for making quantitative predictions of the liquid-injection extinguishment characteristics of the propellant.

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Study of Flow Patterns, Behaviour of 3D Separated Flow on Simplified Space Shuttle Model

92P60265A Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese Vol 10 No 1, Mar 92 pp 21-30

[Article by Deng Xueying [6772 1331 9496] and Zhang Hongwei [1728 1347 0251] of Beijing Aerospace University, Beijing 100083: "Study of Patterns of Low-Speed Flow on [Surface of] a Simplified Space Shuttle Model, Their Three-Dimensional Separated-Flow Characteristics"; MS receipt date not given]

[Abstract] A study of patterns of low-wind-speed (25 meters/s) 3D flow on the surface of a simplified space shuttle model and an analysis of separated-flow characteristics has been carried out at angles of attack (α) varying from 0° to 50°. The experiment was conducted at Beijing Aerospace University's Institute of Fluid Mechanics, and utilized the institute's D-1 return-flow-type open throat wind tunnel, which has an elliptical (1.02-m major axis, 0.76-m minor axis) test-section cross section. The corresponding Reynolds number is 1.7 x 10^6/m. The shuttle model, a simplified version of the U.S. space shuttle, has equal-thickness aluminum plate wings, with tapered leading edges and semicylindrical side and trailing edges. The body consists of a spherical/conical nose cone and a fuselage with a semicylindrical/rectangular cross section, as shown in Figure 1 below. The conventional silicone-oil/titanium-white-powder oilflow technique was used to display the surface patterns. Surface pressure distribution was measured at seven cross-sectional positions along the body, as shown in Figure 1.

Six flow patterns appeared on the upper surface of the wing: (1) attached flow, for α = 0-3°, (2) leading-edge separated vortex flow, for α = 8-13°, (3) leading-edge separated vortex breakdown flow, for α = 15°, (4) wing stall flow, for α = 25°, (5) reverse flow, for α = 40°, and (6) complete separated flow, for α = 50°. These six types are shown below in Figure 2 (a) through (f), respectively. In addition, for the two highest values of α, patterns on the side surface of the hull are shown below in Figure 3 (a) and (b), respectively.

Four main flow patterns appeared on the body: (1) shoulder-bubble flow, for α = 0-3.5°, (2) owl-face flow, for α = 4-6°, (3) simultaneous primary and secondary separation-line flow, for α = 20-22°, and (4) owl-face flow with disappearance of spiral point, for α = 23-25°. These four types are shown below in Figure 4 (a) through (d), respectively. In addition, the topological structure of body-flow type (2), called saddle-point-type open separation, is shown in Figure 5 (b) below, while Figure 5 (a) depicts the topology of the generic closed type of separation.

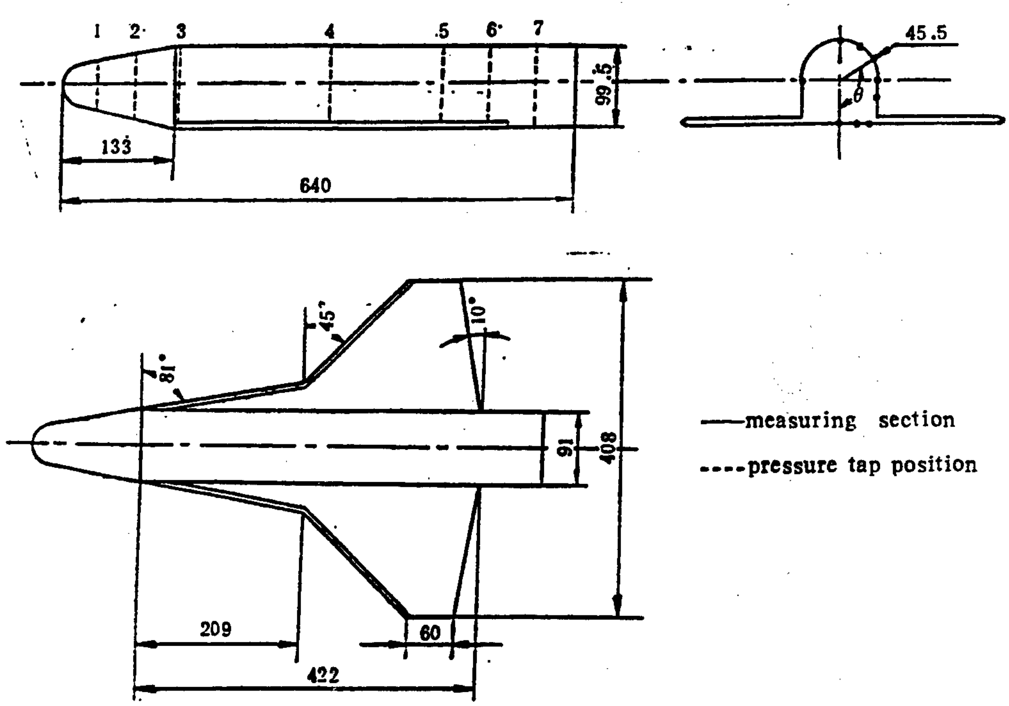
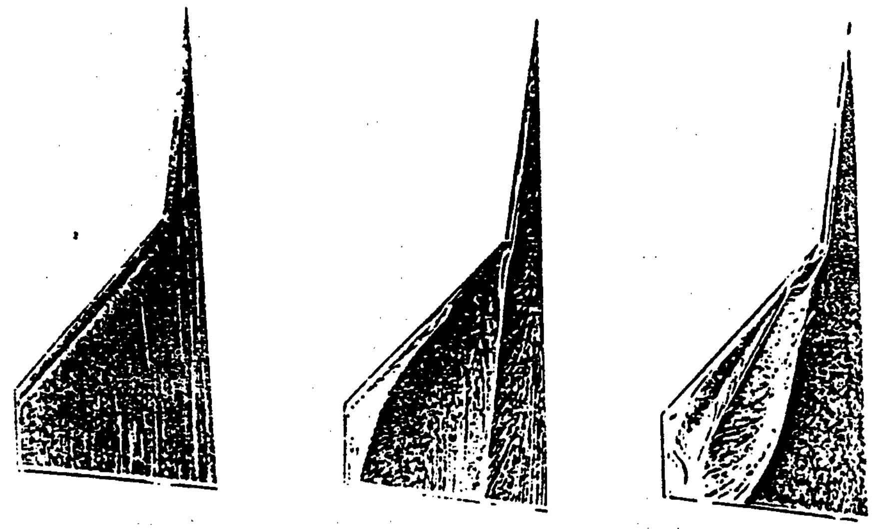


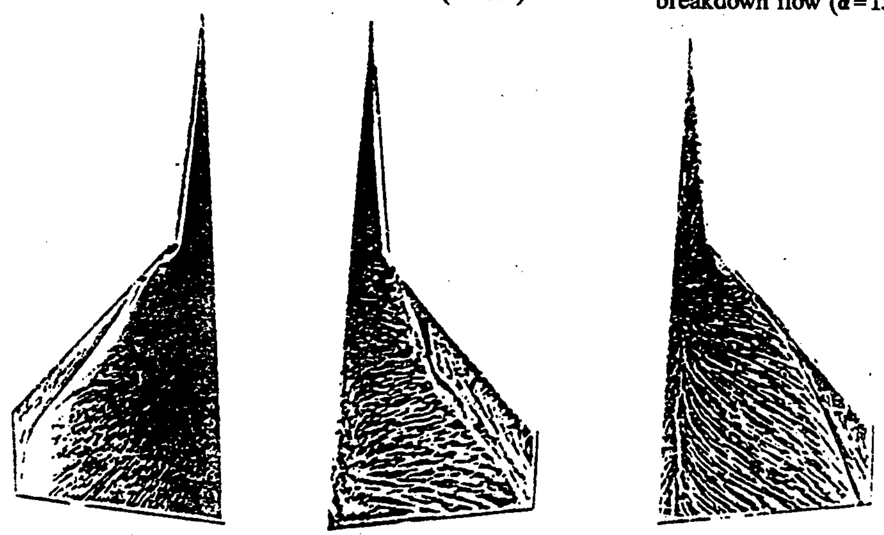
Figure 1. Sketch of Simplified Space Shuttle Model (all measurements in mm)



(a) attached flow ($\alpha=0°$)

(b) leading-edge separated vortex flow ($\alpha=10°$)

(c) leading-edge separated vortex breakdown flow ($\alpha=15°$)



(d) wing stall flow ($\alpha=25°$)

(e) reverse flow ($\alpha=45°$)

(f) complete separated flow ($\alpha=50°$)

Figure 2. Flow Patterns on the Upper Surface of Wing

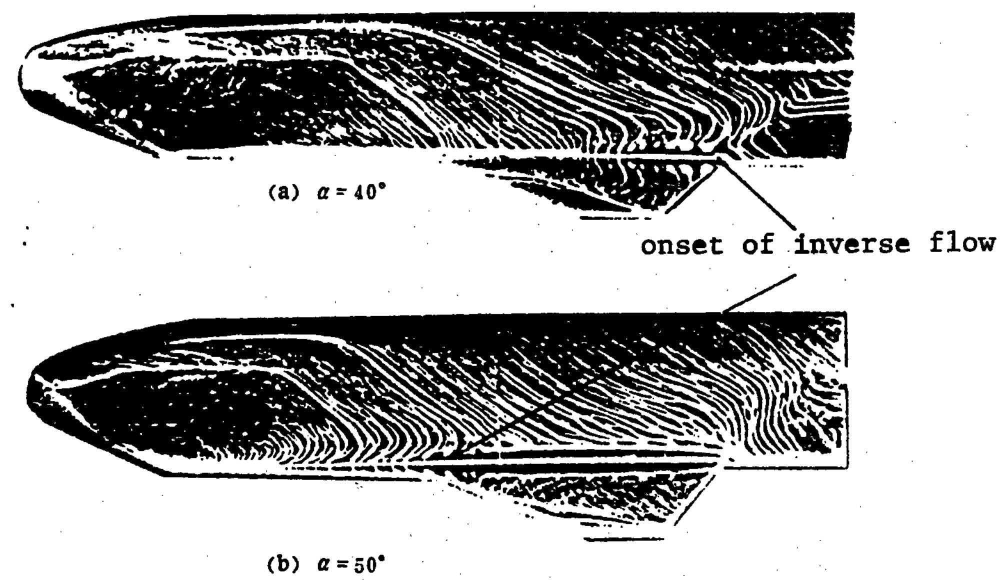
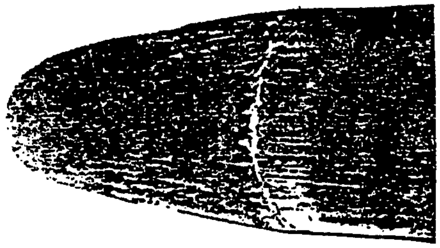
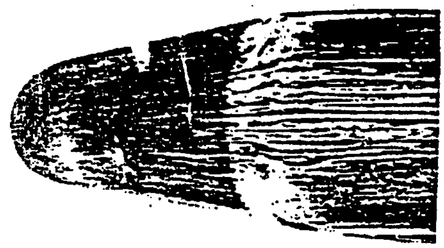


Figure 3. Flow Patterns on the Side Surface of Body

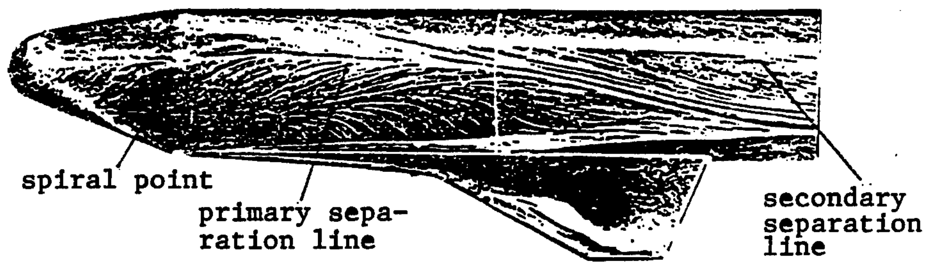
Body-flow type (2), a newly discovered 3D pattern, is characterized by a separation line starting at the saddle point in the surface skin-friction vector field. The flow behaviour of open/closed separation, including pressure gradient features and properties of skin friction-line patterns in the vicinity of the flow separation-line onset point, the separation formation process, and the topological structure of the skin-friction vector field, are discussed in detail. It is found that the newly discovered saddle-point open separation type should be classified as a second kind of closed separation.



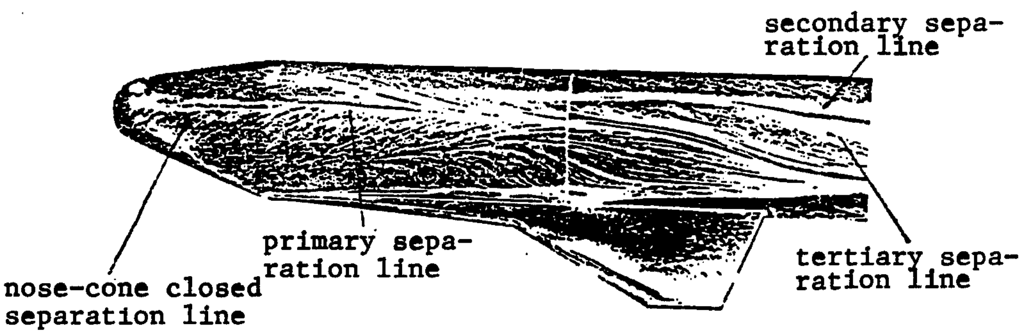
(a) shoulder-bubble flow (top view $\alpha = 0°$)



(b) owl-face flow (top view $\alpha = 6°$)

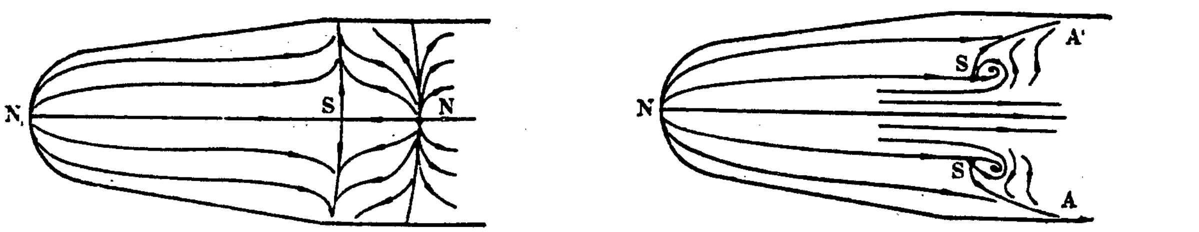


(c) primary and secondary separation flow (side view $\alpha = 21°$)



(d) disappearance of spiral point in owl-face flow (side view $\alpha = 25°$)

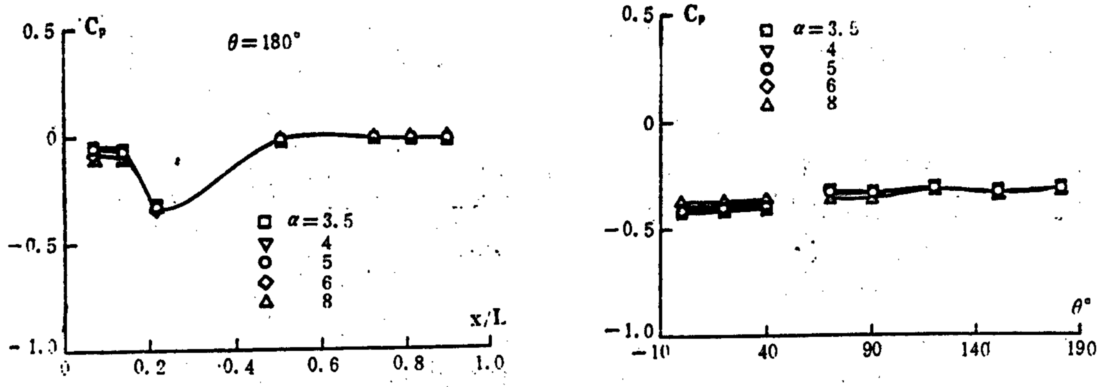
Figure 4. Flow Patterns on the Body



(a) closed separation

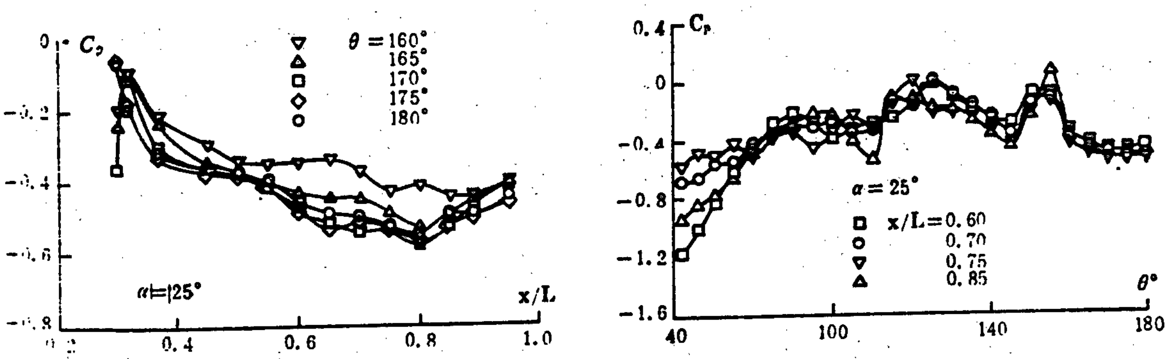
(b) saddle-point open separation

Figure 5. Topological Structure of Closed/Saddle-Point Open Separation Near Separation-Line Onset Point



(a) along streamwise direction (b) along circumferential direction

Figure 6. Pressure Distribution of Closed/Saddle-Point Open Separation



(a) along streamwise direction (b) along circumferential direction

Figure 7. Pressure Distribution of Regular-Point Open Separation

Figure 6 below shows the pressure distribution of the closed separation and saddle-point-type open separation in the vicinity of the separation-line onset point, while Figure 7 shows the pressure distribution of a regular-point-type open separation. Figure 8 [not reproduced], taken from Reference 10, shows the regular open/closed separation transition process.

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Delay of Wing Vortex Bursting by Using Favorable Interaction of Vortices

40100044A Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese Vol 10 No 1, Mar 92 pp 53-59

[English abstract of article by Feng Yanan, Xia Xuejian, Liu Xiaofeng, and Liu Rizhi, of the Beijing University of Aeronautics and Astronautics; MS receipt date not given]

[Text] An experimental investigation into delay of wing vortex bursting for fighter and missile-type wing-body combinations is carried out by means of flow visualizations and force measurements. Both wings of the experimental models have sharp leading edges; a body-strake with high sweepback and small area is fixed to both sides of the body. The fighter-type model has a delta body-strake with 70 deg. sweepback angle, 10.2 percent of the exposed wing span and 2.2 percent of the exposed wing area. There are three strake positions along the vertical direction of the body, i.e., the higher position, the middle one and the lower one. The vortex flow pattern visualization of models with and without body-strake are presented. A comparison of these flow patterns indicates that vortex bursting of the wing in models with a body-strake is delayed efficiently. Longitudinal force and moment data are obtained for the fighter model and comparison between experimental results with and without body-strake are given graphically. This illustrates that the effect of the body-strake can actually increase the maximum lift coefficient and to some extent the critical angle of attack. Experimental results also show that the drag coefficient has some increment in the presence of body-strake over the range of angle of attack; when $\alpha < 10°$, the lift-drag ratio is decreased, but for $\alpha > 10°$, the body-strake has no effect essentially on lift-drag ratio. When using the body-strake, the longitudinal static stability must be considered, because it is decreased.

Aerodynamic Design of Interstage and the Effects of Plume-Induced Flow Separation on Aerodynamics of Rockets

40100043D Beijing YUHANG XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 2, Apr 92 pp 95-98

[English abstract of article by Wan Yin of the No. 1 Design Department of the First Research Academy, the Ministry of Aerospace Industry; MS received 25 Feb 91]

[Text] Stage-separation features of multistage rockets with solid and liquid propellants are described. The differences of the two sorts of rockets in exhaust holes and stage-separation aerodynamics are analysed. The effects of the exhaust holes and their area, amount and shape on interstage pressure and thermal environment are discussed.

Above some altitude within an atmospheric layer, the boundary layer on the afterbody will separate due to plume. The effects of such plume-induced flow separation on the aerodynamics of rockets are discussed, especially the derivative of normal force with respect to angle of attack, pressure center and axial force. Some experimental results are presented.

Study on Space Tethered Satellite System Dynamics and Control

40100043C Beijing YUHANG XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 2, Apr 92 pp 87-94

[English abstract of article by Yu Shaohua of the Space Science and Application Research Center, the Chinese Academy of Sciences, Beijing; MS received 5 Mar 91]

[Text] As a new space research tool, the tethered satellite system is a space technology now under development. The problem of system dynamics and control is considered unsolved so far. A tether-length rate control algorithm has been described in this paper, based on a dynamics study by the state plane method. This algorithm has successfully solved the stability and control problem in all deployed, station-keeping and retrieval modes of the system operation. A computer simulation of two- and three-dimensional motion of the system under the assumption that the tether is considered a a massless and inextensible cable is provided.

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High-Precision Tracking Algorithm for Space Infrared Spot Target Images

40100043B Beijing YUHANG XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 2, Apr 92 pp 41-47

[English abstract of article by Li Jiang, Chen Huihuang, Ji Ming, and Lu Huanzhang, of the National University of Defense Technology; MS received 19 Dec 90]

[Text] The problem of tracking a space moving target via its infrared images is studied. A new adaptive tracking algorithm with high tracking precision has been put forward; a Kalman filter and a temporal image smoothing algorithm are included in it. Monte-Carlo experiments have been done and show that this tracking algorithm has good performance and high tracking precision.

Effect of Step Aging on Stress Corrosion Resistance of Al-Li Alloy

40100043A Beijing YUHANG XUEBAO [JOURNAL OF THE CHINESE SOCIETY OF ASTRONAUTICS] in Chinese No 2, Apr 92 pp 27-33

[English abstract of article by Li Renshun, Chen Xiangping, He Jun, of the Harbin Institute of Technology; MS received 10 Sep 90]

[Text] Comparing with single-stage aging the influence of a stepped aging process on stress corrosion resistance is studied in 2091 Al-Li alloy by using slow strain rate tension and three-point-bending specimens. Experimental results show that a stepped aging process not only enhances mechanical properties but also improves resistance against stress corrosion of the alloy. The mechanism of stress corrosion in the Al-Li alloy is also discussed.

Military Electronics Research Areas Highlighted

92P60269B Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 1 May 92 p 1

[Article by Xia Yuzhi [1115 6235 5365]: "Military Electronics Advance Research Enters Critical Period"]

[Summary] It has been learned from the Military Electronics Advance Research Work Conference sponsored by the CHINATRON Corp. and held in Beijing 18-22 April that advance research in military electronics is entering a critical new phase in the current (Eighth) 5-year plan. CHINATRON Corp. Assistant General Manager Wang Jincheng [3769 6855 1004] revealed that in the conference attendees' assessment of the Seventh 5-Year Plan, 1,885 state projects in military electronics advance research were completed, and 1,829 specific results were obtained, with 840 results meeting 1980's international standards. Research areas included microelectronics technology, optoelectronics technology, microwave electro-vacuum devices, electronic warfare technology, radar detection technology, military communications technology, military computer technology, specialized electronic components and devices, and fabrication technologies, all of which have raised the quality of military electronics products and shortened lead times. In the Eighth 5-Year Plan, he stressed, attention will be paid to management concepts such as systems engineering management, to faster conversion of scientific results into products, improved training, construction of new defense-related laboratory facilities, and increased international cooperation and international exchanges.

Adaptive Antenna Basic Technology and Applications Project Passes Appraisal

92P60269A Beijing DIANZI XUEBAO [ACTA ELECTRONICA SINICA] in Chinese Vol 20 No 4, Apr 92 inside back cover

[Article by Wang Jun [3769 0193]: "Study of Adaptive Antenna Basic Technology and Applications Passes Technical Appraisal"]

[Summary] A research project on adaptive antenna basic technology and applications undertaken by engineers in the Space-Domain Signal Processing Laboratory of Xidian University's Department of Detection and Instrumentation passed the technical appraisal organized by the CHINATRON Corp. on 16 December 1991 [in Xian]. The project consists of the following three technical achievements:

(1) Transmit/Receive (T/R) Compatible-Operation Local Interference Adaptive Cancellation Technology. In tight areas such as on warships and planes, the transmitter can have an adverse effect on the receiver, a condition traditionally rectified by time-division and frequency-division methods. This subproject includes development of a T/R compatible-operation local interference adaptive canceller incorporating power inversion (reflection) techniques. The main performance parameters for this adaptive canceller are as follows: operating band is 25 MHz-30 MHz, signal bandwidth is less than or equal to 50 kHz, input-end induced voltage is less than or equal to 1 V, and cancellation ratio for same-frequency operation exceeds 50 dB.

(2) Receiver Outside-Source Same-Band Interference Adaptive Cancellation Technology. In the majority of cases where systems are used in a real environment, such as in [electronic] intercepts and detection, one does not have a priori knowledge of a useful signal. This subproject includes the first [domestic] formulation of a modified LMS [least mean square] adaptive algorithm and introduction of a loop filter incorporating conformance filtering and spectral-peak shift technologies. This subproject also includes development of a receiver external-source same-band interference adaptive processor prototype, which operates in the shortwave band (2-30 MHz) and has a cancellation ratio of 15 dB to 20 dB; it represents a major contribution to domestic adaptive space-domain filtering technology.

(3) Orthogonalized Preprocessing Technology. This subproject is oriented toward solution of problems in multielement arrays introduced by spreading of characteristic values over long time periods, and includes development of a three-element adaptive orthogonalized (quadrature) preprocessor prototype or principle demonstrator. In the 3.2 MHz-6.2 MHz band, this prototype can perform orthogonal correlation of three narrow-band signals with a convergence time of under 200 μs.

Two New Aluminum Nitride Ceramics Certified

92P60285 Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 4 May 92 p 3

[Article by Lu Shaoming [0712 4801 7686]: "Two Institute 43 Achievements Pass Appraisal"]

[Summary] Two projects of MMEI's Institute 43—"Aluminum Nitride (AlN) Ceramic Substrate" and "AlN-Tungsten Multilayer High-Temperature Jointly Sintered Ceramic Technology Research"—recently passed design finalization and technical appraisal, respectively. The AlN ceramic substrate's thermal conductivity is 110-180 W/M.K, average linear expansion coefficient is (4.0-4.4) x 10^{-6} per degree, breakdown strength exceeds 15 kV/mm, and bulk resistivity exceeds 3.3 x 10^{14} Ω-cm, performance parameters which approach those of the comparable Japanese-made product, Kyocera's AN215. The AlN-tungsten multilayer high-temperature jointly sintered ceramic technology project uses a forming method including doctor blading process, thick-film printing, layer-by-layer ceramic growth, and normal-temperature sintering. The material's thermal conductivity is 120 W/M.K, fracture strength is 29 kg-f/mm^2 (average value), and the number of layers is 5-7. Its main performance indicators are equivalent to those of mid-eighties internationally advanced technology.

World-Class Carbon Fiber Composite Developed by Nanjing Institute

92P60270A Nanjing JIANGSU KEJI BAO in Chinese 22 Apr 92 p 3

[Article by Shao Jianhua [6730 1696 5478]: "Nanjing Develops Carbon Fiber Composite Packing Material"]

[Summary] A new type of specialized high-performance packing material called carbon-fiber-reinforced polytetrafluoroethylene and developed by a research team led by Associate Professor Dr. Gong Liehang [7895 3525 5300] from the Machinery Teaching and Research Section of Nanjing Institute of Military Engineers recently passed expert technical appraisal. The new material's main performance indicators meet or exceed the international state-of-the-art.

Carbon-fiber-composite packing materials are widely used in the aerospace, nuclear power, chemical engineering, petroleum, iron and steel, and machinery industries. This particular type can withstand temperatures as low as minus 180°C and as high as plus 300°C, and in comparison with the leading foreign-made product it has a compressive strength over 90 percent higher, a tensile strength about 20 percent higher, and other superior performance parameters—friction coefficient, polishing scratch width, softness, and resilience. The new material's useful lifetime is seven or eight times that of the leading imported product, and its cost is only one-fifth that of the imported product.

Taiji 2433-MP Multiprocessor System Described

92P60271B Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 15, 15 Apr 92 p 67

[Article by Wang Zuyong [3769 4371 3057] of the North China Institute (NCI) of Computer Technology: "Theory, Practice of Multiprocessors"]

[Summary] In an effort to promote development in the nation's minicomputer industry, NCI has recently perfected the OSI-compatible Taiji 2433-MP message-passing multiprocessor computer system. The Taiji 2433-MP is a bus-type shared internal memory multiprocessor system with a maximum of six processors and 64 Mbytes of shared memory. It is a near-fully-symmetric system—not a fully symmetric system; one CPU acts as the basic CPU. The system includes BIOS ROM and diagnostic ROM, a 64 Mbyte/s Cache bus for connecting the CPUs with the on-board RAM, a standard I/O bus and an ISA bus. When it has the full complement of six 33 MHz i486 CPUs, the Taiji 2433-MP system has an overall operating speed approaching 120 MIPS. Via a variety of network cards, the system can support Novell Netware 3.11, LAN manager 2.0, Ethernet, 10Base-T, TCP/IP, and NFS. The new multiprocessor system operates under the SCO UNIX V/386 3.2 or SCO Open Desktop environments.

Taiji 2433 Multiprocessor System, AP2900E-Series Array Processors Unveiled at Expo

92P60271C Beijing JISUANJI SHIJIE [CHINA COMPUTERWORLD] in Chinese No 16, 22 Apr 92 p 1

[Article by Hai Ping [3189 5493] and Xiao Chen [2556 6591]: "North China Institute Holds '92 New-Product Exposition"]

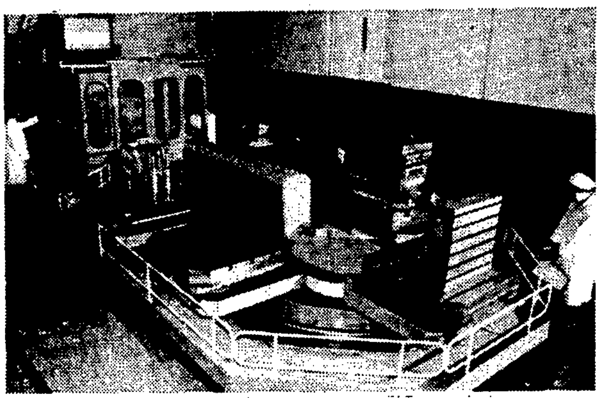
[Summary] On the first day (8 April) of its '92 New-Product Exposition, North China Institute (NCI) of Computer Technology unveiled several advanced new systems to an audience consisting of representatives from MMEI, the State Council's Office for Promotion & Application of Electronic Information Systems, the CHINATRON Corp., the Ministry of Energy Resources' Petroleum Division, the Ministry of Railways, and NDSTIC, as well as the general public. At the 10-day event, about 100 new NCI products and technologies were unveiled, chief among which are: 2D and 3D RISC-based workstations with enhanced graphics functions; superminicomputer(s); the 120 MIPS Taiji 2433 multiprocessor system, with up to six 386 or 486 CPUs; the AP2900E series of array processors, with ECL [emitter-coupled logic] circuit technology and a performance of 40 MFLOPS; a variety of Taiji LAN and WAN systems and equipment for interconnecting SUN-UNIX, VAX-VMS, ULTRIX-UNIX, MIPS-UNIX, PC-DOS, and PC-UNIX; the M2234 ruggedized superminicomputer, with an operating-temperature range of -5°C to +55°C and a MTTF of 20,000 hours; 486DX and 486SX-based microcomputers and multimedia microcomputers; a computer monitoring system for a 500 kV transformer station; and several banking and commercial networked and MIS systems.

First Domestically Developed FMC for Precision Casings Certified

92P60277A Urumqi XINJIANG RIBAO in Chinese 14 Apr 92 p 3

[Untitled photoreport by XINHUA staff writer; photo by Zhou Zhongyao]

[Text] The first domestic precision-casings flexible manufacturing (machining) cell (FMC), developed by the Kunming Machine Tool Plant, passed state-level appraisal on 16 February. This large precision machine tool, meeting mid-eighties international standards, can simultaneously work on six casing parts, and automatically complete a variety of machining processes—drilling, boring, milling, reaming, etc.—on these parts. An inspection of finished products indicated that 100 percent are up to standard.



Nation's First FMC for Precision Casings

Status of Domestic Flexible Manufacturing Technology, Analysis of Developmental Strategy

92FE0405A Dalian ZUHE JICHUANG YU ZIDONGHUA JIAGONG JISHU [MODULAR MACHINE TOOL AND AUTOMATIC MANUFACTURING TECHNIQUE] in Chinese No 2, Feb 92 pp 29-38

[Article by Xu Jiamo [1776 0857 2875] of Dalian Modular Machine Tool Institute (DMMTI): "Development Trend of Flexible Manufacturing Technology Worldwide, Analysis of Domestic Development Strategy"]

[Excerpt] [Passage omitted]

3. Status of Domestic Flexible Manufacturing Technology, Analysis of Developmental Strategy

3.1 Status

3.1.1 There is a huge gap between China and other countries in the production and use of CNC (computer numerically controlled) machine tools.

Domestic production of CNC machine tools suffers from low capacity, lack of variety and poor quality. Inadequacy in CNC technology makes it impossible to match with the primary tool. Approximately 70 percent of the [type of] CNC and servo systems imported are now produced domestically; however, they are all in pilot production. Of course, there are a few good CNC systems, such as the "Lantian 1" CNC system [see JPRS-CST-91-006, 5 Mar 91 pp 20-21], and they have obtained a share in the marketplace worldwide.

Table 4 is a comparison of percentage of CNC machine tools in China and Japan in 1988.

Table 4. Comparison of Percentage of CNC Machine Tools in China and Japan

Country	Machine tool types	CNC machine tool types	CNC types as percentage of all types	Output of CNC machine tools as a percentage of output of all machine tools	Output value of CNC machine tools as percentage of output value of all machine tools
Japan	2,000	1,322	65%	28%	70%
China	250 [sic, ?2,350]	178	7.5%	1.3%	6.15%

In the Eighth 5-Year Plan, CNC machine tools will be developed considerably. They will grow from 200 types to 400 and the annual output will increase from 4,000 units to 8,000-10,000 units. The output of CNC machine tools as a percentage of output of all machine tools will increase from 1.3 percent to 5-6 percent (including 1,000 machining centers [MCs]/year, as well as CNC boring and milling machines, CNC lathes, CNC grinders, CNC electromachining machine tools, CNC forging pressures, etc.).

3.1.2 Development and application of FMCs have just begun.

There are only a few flexible manufacturing (machining) cells (FMCs) in China and the number of imported units is also low. Most of the 15 FMCs scheduled to be developed in the Seventh 5-Year Plan have been successfully completed. These include manufacturing cells for milling, turning, multi-axis modular machining, die casting, molding and sheet bending. Most of these products were developed based on imported technology. Domestic production only accounts for a very low percentage and domestically made products have not been rigorously evaluated in the field. Similarly, independently developed products also do not have a sufficient track record in operation; they have not been rigorously

challenged in the field. Hence, product specifications have not been fixed and no product has been commercialized. Therefore, it is impossible to compare domestically manufactured FMCs with their foreign counterparts in terms of quality and quantity. Nevertheless, China has taken the first step in developing and applying FMC products. Furthermore, domestic production started at a relatively high level. Several independently developed products are fairly unique. For instance, the flexibility and high efficiency of our multi-axis modular FMC are well received by the users. We have received some orders already.

3.1.3 The FMS is essentially in the research and development stage.

China has a very fragile foundation for the development and application of flexible manufacturing systems (FMS) and the progress has been very slow. There are only seven FMSs installed and put into full or partial operation (see Table 5). Moreover, they are all imported products, including FMSs for machining casing parts, rotating parts and sheet-metal parts. There are approximately 10 independently developed FMSs; some now being developed and others now in design. None has been completed.

Table 5. List of FMSs in Operation in China

Model number	Development organization	User	Machine tool type	Number of machine tools and transport mode
JCS-FMS-1	Beijing Machine Tool Institute and FANUC Corporation, Japan	Beijing Machine Tool Institute	Axles, disks, motor cases	5 units, AGV, robots
FFS-500-2	Werner & Kolb, Germany	Jianglu Machinery Plant, Xiangtan	Casings	2 units, RGV (two vehicle transport pallets, cutting tools)
FFS-1500-2	Werner & Kolb, Germany	Zhengzhou Textile Machinery Plant	Sheet-metal cases	2 units, RGV
—	Murata, Japan	Liuzhou Switch Plant	Sheet-metal parts	2 units, AGV
—	Germany	Shenyang Aircraft Mfrg. Co.	Aircraft panels	4 units, RGV
FMS80	Dalian Machine Tool Plant (DMTP) and KTM Corp., U.K.	DMTP	Machine tool bodies	3 units (2 units already installed and running), RGV
DENFORDFMS	DENFORD Co., U.K.	East China Institute of Engineering	Rotating bodies	2 units, conveyor

Among the FMSs described above, five of them were focal-point projects in the Seventh 5-Year Plan. One of the FMSs is primarily used to make servo motor shafts and disks (JCS-FMS-1). It consists of five CNC machine tools and employs two industrial robots to change tools for the CNC units. The entire line uses an automatic guided vehicle (AGV) to deliver materials. The cell-control systems, robots and AGV were imported. The line is based on the Japanese FANUC technology for developing a central control system. This line has been installed and is in operation. Another line, the FMS80, is used to machine machine-tool casings. It is comprised of three MCs and a rail guided vehicle (RGV). Two MCs, the materials transport system and the PDP 11/23 main computer control system were imported from KTM Corporation in the U.K. The two-MC system is already on line, while the third MC is currently under development (based on KTM technology) and will be incorporated into the system. Two other FMSs are used to make refrigerator compressor housings (ZHS-FMS01) and machine-tool housings and parts (ZHS-FMS03). Both have four independently developed multi-axis FMCs and an RGV system (the former has an extra washing unit). On the basis of KTM's FMS management software, DMMTI developed the ZHS-FMSS-11 central control and management system [software; see JPRS-CST-90-025, 1 Oct 90 pp 13-16]. The Seventh 5-Year Plan goal for FMS01 was revised to one FMC, which has been officially certified. FMS03 is still under development. The plate (sheet-metal) FMS in the Seventh 5-Year Plan is also under development. It consists of a punch, a shear and a sheet-metal warehouse for machining high- and low-voltage switch boxes. In addition, a plate-machining FMS CAD/CAM system has been developed based on the plate FMS automatic programming system technology developed by Wiedemann Corporation of the United States and Murata Corporation of Japan.

The above is a brief description of the status of the five FMSs in the Seventh 5-Year Plan. Although the FMS systems to be independently developed are still not yet finished, many items associated with the FMS systems have been accomplished in the Seventh 5-Year Plan. This has laid down a solid foundation for projects in the Eighth 5-Year Plan and even farther out into the future. These accomplishments include:

- Research and development of FMC-related technology and products with a variety of machining capabilities, and construction of a demonstration FMS with a simple MC and RGV storage and transport system.

- Construction of FMS materials storage and transfer systems, including pallet, pallet exchanger, RGV system, AGV system, and three-dimensional warehouse.
- FMS basic technology, including study of MC structure and performance, especially FMS design and planning software such as CAPP [computer aided process planning] for casing parts, FMS load balancing, operation optimization, FMS digital simulation and real-time video simulation system, FTL [flexible transfer line] dispatch optimization software, and FMS physical analog simulation system [see JPRS-CST-90-025, 1 Oct 90 pp 16-19].
- FMS central computer control and management software.
- Ancillary techniques such as high flow cooling and filtration and shaving processing.

It should be pointed out that further work is required to develop reliable products and the associated software, such as CNC systems, tool wear-and-tear monitors and integrated FMS monitors, to be integrated with FMCs and FMSs in order to provide the environment for a CIMS [computer integrated manufacturing system].

3.2 Analysis of FMS Development Strategy in China

First, FMS involves many disciplines at great breadth and depth. It is impossible for an individual to get a clear picture about its development trend worldwide in a short period of time and then present a strategic plan that meets the needs for China. Therefore, the following is a list of my personal recommendations and any comments from the leadership and readers are welcome.

Next, 75-80 percent of the FMSs for casings, rotating bodies and sheet-metal work is for machining casings. Such parts are relatively complex to make, which makes flexible manufacturing of more interest worldwide. The following recommendations are more relevant to this area (nevertheless, they also involve other common issues):

3.2.1 Speed up the development of new CNC machine tools to raise the percentage of CNC.

3.2.1.1 Development of CNC modular machine tools

As discussed before, a large number of modular machine tools and automated modular-machine-tool-based production lines were installed in the 1970's in China's automotive, tractor and other mass-production industries. There is an urgent need to modify and upgrade these rigid production lines in order to add more flexibility to accommodate a variety of new products. This is a large market and CNC modular machine tools have a bright future in this market. Market Intelligence Research Co. predicts that the annual sales of station machines (conventional modular machine tools and the associated automated line) by 1992 will fall to 7.7 percent from 16.4 percent of total sales of machine tools in 1986. In 1989, US$295 million worth of FMSs and FMCs were sold. This will increase to $520 million worth in 1993. This trend shows that medium and large throughput industries are moving toward flexible manufacturing.

The following CNC modular machine tools should be developed:

- CNC rotating-tower modular machine tools (including single-axis and multi-axis rotating towers, box width below 500 mm).
- CNC interchangeable-box modular machine tools (vertical chain-driven box magazine, single- or double-sided, box width over 630 mm).
- Specialty CNC modular machine tools (CNC mechanical-platform-based modular machine tools equipped with various cutting tools, such as CNC modular milling machines, CNC modular borers, and CNC modular bore-hole end-face lathes).

These machine tools are structurally simplified by CNC, but the layout and interchangeable dimensions still meet modular machine standards.

We should develop modular machine tools and FTL low-cost modular CNC systems, such as multiple-control-axis ac servo location control systems, multi-axis ac/dc servos suitable for complicated modular machine tools and automated production lines, and dedicated PC-based CNC systems. Domestically, we have developed dc servo cells, ac servo devices, and single-coordinate ac servo NC systems. These are modules developed for CNC modular machine tools and FTL control systems. They may be installed based on the number of axes and functionality and they are simple, reliable and inexpensive.

3.2.1.2 Development of in-line centers

An in-line center is an MC which can be linked into a production line, such as the CNC-flexmodule manufactured by Honsberg Corporation of Germany. There are similar domestically made products that are waiting to be evaluated. The unique features include three overlapping coordinates, narrow width and small tool-magazine capacity (4-12). They can easily be incorporated into a flexible automated line.

3.2.1.3 We should develop modular single- and multiple-axis FMC systems (basic models have been developed, see Figures 2 and 3).

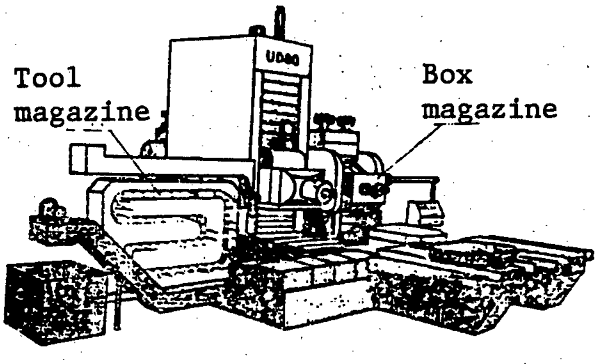


Figure 2. Model UD 80 Tool-Change/Box-Change FMC (Designed by DMMTI, developed by Qinghai Machine Tool Plant No. 1)

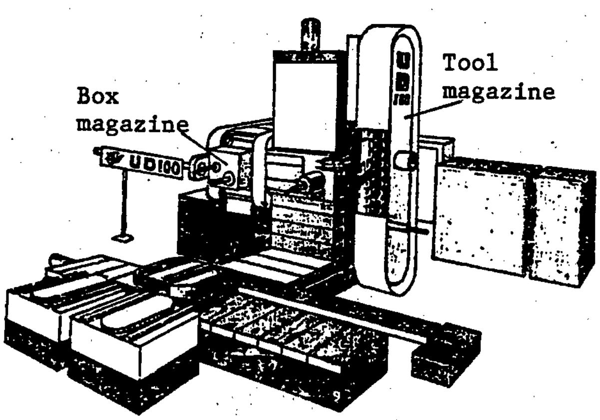


Figure 3. Model UD 100 Tool-Change/Box-Change FMC (Designed by DMMTI, developed by DMTP)

Here, a flexible machining cell is a machining module that can be used to form an FMC or FMS. Its multi-axis version can be used to form an FTL.

Such an FMC behaves like a building block which significantly increases the flexibility of the system layout and capability. Since the tool magazine, multi-axis box and XYZ (three-coordinate) NC slide platform and main-axis drive box are independent modules, a variety of machine tools with different structures and capabilities can be formed by selecting a different combination of modules to meet different flexibility and efficiency requirements for small, medium and large-batch production. Let us use a Model UD cell, which meets the specifications of an 800 x 800 mm pallet, as an example to illustrate the situation. UD80 is the base model. It has a tool magazine, a box magazine and a three-coordinate slide platform. It can perform single- and multiple-axis machining. There are three types of tool-magazine capacities, 60, 120 and 180. There are three types of box-magazine capacities, i.e., 4, 8 and 12. The tool magazine is vertical and the basic modules consists of a set of 60 tools selected according to need. The box magazine is also vertical. It is selected from independent modules based on capacity requirement. UDb80 is a modified version which only has a box magazine (either single-sided or double-sided and selected based on capacity and box-changing speed). It is used in multi-axis machining (of course for high-volume production). However, rigid milling tools, rigid boring tools, bore-hole end-face lathes and oblique rotary main-axis tools may be used instead of the multi-axis box to perform single-axis machining (for some large surfaces, holes, countersinks and inclined holes, which are more difficult to accomplish by conventional MCs). The UDc80 is also a modified version. It only has a tool magazine for single-axis machining. However, it is possible to install a small multi-axis head with a handle within the reach of the mechanical arm to conduct some multi-axis machining. These two modified single- and multiple-axis MCs are essentially identical to the ORION series of products manufactured by Comau Corporation in Italy. In addition to these three basic models, the flexibility and number of platforms may decrease. For instance, based on the position of machining required, it is possible to form a double-axis or single-axis dedicated NC milling machine, NC bore-hole end-face lathe, and NC multi-axis machine tool. The building block nature of the structure and machining capability permits the system to vary in both directions, i.e., either toward a simpler system or a more sophisticated system. This is essentially the same idea as the MACH series of CNC modular machining systems made by Honsberg.

3.2.2 We should develop the FTL.

3.2.2.1 What is an FTL?

The FTL, which stands for flexible transfer line, is also known as a flex-line system. Since a computer is used to implement real-time numerical control of the machining modules in the line, it is more flexible than a conventional transfer line. It is more adaptable to making a variety of parts. It is capable of completing all the processes done on a conventional line and can handle larger-batch sizes.

The FTL is commonly used to machine a closed family of workpieces. It usually employs a pallet synchronous transfer system with a fixed rhythm. Sometimes an asynchronous roller or robotic transfer system may also be used.

Most FTL machining modules are composed of NC modular machine tools, in-line centers and multi-axis FMCs, as described above. Conventional modular machine tools may also be used if the process is limited to a certain location. Different machining modules may be selected based on types of workpieces to be machined, techniques involved and production rate required to assemble a flexible and efficient FTL.

3.2.2.2 Vitality of the FTL market

In the first half of the 1980's, other countries were chasing after flexibility. In the latter half of the 1980's,

they were seeking both flexibility and a high rate of production. In the medium- to long-term technical development outline for the electronics and machine-building industry in China, production equipment for the automotive industry must be highly efficient, precise, automated and flexible. This usually involves an automated line. The advantages of a single computer on-line system have been discussed before. The following is an introduction to a few FTLs developed by the CROSS Corporation (U.S.) and shows why the FTL is so attractive to users:

- An FTL for machining 70 different kinds of supports and end caps is composed of 10 in-line centers, an asynchronous clamp transfer system and a computer control unit. It is operating at a beat of 9 seconds and its operating efficiency is 93 percent. Only 7 percent of the time is used for changing tools and replacing worn-out parts. It essentially operates around the clock all year.
- An FTL for machining three types of cast-aluminum and three types of cast-iron exhaust pipes is comprised of two transfer lines. It employs a rotating-tower power head and a multiple clamp transfer system to produce 120-150 parts per hour.
- An FTL for machining nine types of transmission housings consists of four transfer lines. It employs a number of automatic box-change machine tools and in-line centers and uses robots to load and unload materials. The beat is 18 seconds. It only takes a minute to switch to another product. More importantly, the entire line is equipped with ac servo systems manufactured by Indramat, a subsidiary of MANNESMANN REXROTH.

3.2.3 We should develop low-cost FMSs.

China began to get engaged in the development and application of microelectronics and computer technology at a later stage. There is no sufficient experience in the development and application of sophisticated flexible NC products. In some advanced CNC systems, the key elements still need to be imported. High-tech products cannot be manufactured and integrated into systems. Furthermore, China's economy is weak. There is a shortage of capital to invest in technology. Therefore, we have three "major problems" associated with the development and application of FMSs, i.e., high degree of difficulty, large capital requirement and high risks. The following is an analysis of whether a low-cost FMS structure can avoid or minimize the concerns associated with these three problems.

3.2.3.1 What is a low-cost FMS?

(A) The FMS (flexible manufacturing system) concept involves a manufacturing system comprised of a number of CNC machine tools and other automated equipment (such as washing machines, measuring gauges, etc.), a material transfer system and an information control system. It is managed by the central computer to make it an automated manufacturing system. This system can machine a series of workpieces which require different processes and beats in any order. The flow may be adjusted according to the workpiece in order to adequately balance the utilization of resources in a timely manner. Hence, this system can automatically adapt to the workpiece and production scale within the capability of the equipment and technique.

The U.S. firm Cross & Trecker Co. named such a system as a full-scale FMS (see Figure 4). Such a system often has several different machines to make a number of parts (typically 2-50 types). The layout may be linear, closed or convoluted-loop-shaped. The transfer system may be chain-driven, AGV-based, robotic, or a combination of these. The system is usually fairly large and technically sophisticated. The down time is substantial and the capital investment is high.

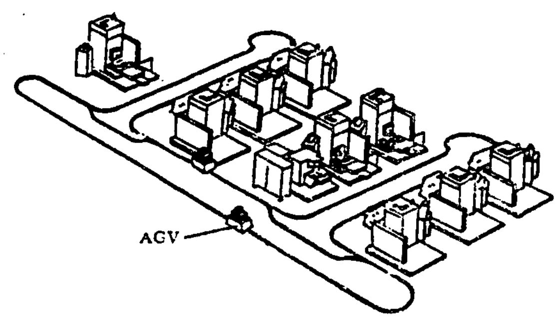


Figure 4. Full-Scale FMS

(B) The low-cost FMS concept, also known as limited-scale FMS (see Figure 5) concept, is as follows:

This kind of FMS can perform the basic function of a full-scale FMS. It is only limited in structure and technique. For example, it has 2-7 identical machines, an optional washing machine or measuring gauge and a linear RGV layout. It can be used to make a family of 2-15 housings or a few housing components. It is suitable for producing 3,000-30,000 parts annually.

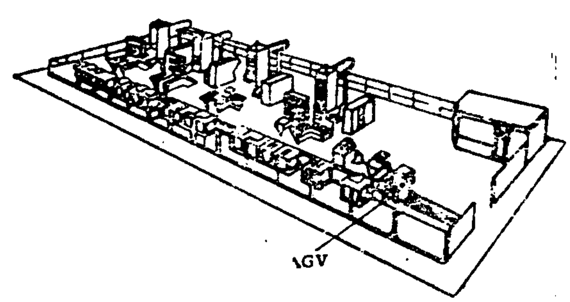


Figure 5. ZHS-FMS03 Limited-Scale FMS (Designed by DMMTI, developed by Qinghai Machine Tool Plant No. 1)

The limited-scale FMS is the product concept and layout promoted by Japanese and western manufacturers since 1980. The Werner-Kolb FFS-500-2 and FFS-1500-2, imported by the Jianglu Machinery Plant in Xiangtan and the Zhengzhou Textile Machinery Plant, respectively; the FMS80, developed by DMTP with major hardware and software imported from KTM of the U.K.; and the ZHS-FMS03 designed by DMMTI and developed by Qinghai Machine Tool Plant No. 1, all belong to this type.

3.2.3.2 Maximum flexibility of limited-scale FMS—generality and expandability

The maximum flexibility of a limited-scale FMS is reflected in the overall modular structure, its generality in terms of hardware and software compatibility, and expandability. The entire system is divided into six major modules, i.e., machining module (including machine tools, pallet-change device and CNC control unit), transfer module (RGV and ground equipment), storage module (pallet and pallet station), loading/unloading module (loading station), ancillary module (washing machine and measuring gauge), and central control module (main computer and peripheral hardware and software). These modules are individually functional and independent. However, there are hardware and software interfaces to link and expand modules in different combinations based on demand. For instance, the number of machines may be increased, the transfer distance may be lengthened, the number of pallets and stations may be increased, the kind of ancillary machine may be selected, and the number of workstations controlled by the main computer may be varied. This flexibility makes it possible to avoid the three "major problems" discussed earlier. The user may gradually expand the scale of its manufacturing line based on availability of capital. The initial investment is low and it takes less time to get on-line. The system is simple and reliable and the risks are minimal. This is called a "step-by-step manufacturing system" by KTM Corporation. It is recommended to purchase a single-machine system first to gain some experience and accumulate some capital. The second step is to add a transfer vehicle or several pallet stations to form a demonstration FMC or FMS in a straight-line APC [automatic pallet change] layout. Next, one or more similar machines will be added based on need and availability of funds. In addition, more stations are to be added and a computer control and monitoring system is to be incorporated to form a limited-scale FMS.

This type of limited-scale FMS has become a fixed model. The overall system may be standardized according to pallet specifications and system scale (number of machines). A series of designs can be made to facilitate the making of standard components to improve reliability and product quality and to reduce production cycle.

3.2.4 Effective measures should be taken to improve the reliability of the FMS.

Reliability of flexible manufacturing equipment is an issue of great concern. It directly affects the rate of utilization of the equipment and has a direct impact on profitability and time of return of investment. To the extent possible, MTBF (mean time between failures) should be optimized and MTTR (mean time to repair) should be minimized.

The following is a list of 10 areas to work on:

(1) Establish technical standards and acceptance conditions for NC machine tools, CNC machine tools, MCs, FMCs, FMSs and FTLs as soon as possible.

(2) Design work should be done in a modular, standardized and interchangeable manner for a series of products. Basic models must pass rigorous production tests before widespread field use. Standard modules can be prefabricated to improve quality.

(3) Use over-hardened NC control systems and high-quality components.

(4) Use robust sensors to enhance monitoring of wear-and-tear on tools and strengthen capability to measure machining dimensions and compensation function in order to provide better failure diagnosis and dynamic system monitoring.

(5) Use FMS design software to accurately formulate an FMS scheme. Use an analog simulation program to model the computer control software.

(6) Be the user first before becoming a supplier. A product should be fully evaluated in production. This is particularly true for new products.

(7) Enhance technical training of the operators and maintenance personnel to minimize or prevent operator error. Programming level and repair and maintenance skills should also be improved.

(8) Formulate scientific design programs and manufacturing and testing procedures for flexible manufacturing equipment. Establish maintenance systems and create a good manufacturing environment. To the extent possible, use computers to establish an overall quality-control system.

(9) Select outstanding business and research institutions to form a new group to manufacture new products, including the main unit and its general-purpose modules. Continuously develop new products to create new markets in order to stay at the cutting edge of technology to ensure quality.

(10) Combine research and development, production and applications.

It is necessary to effectively combine research and development, production and applications in order to have

reliable FMSs. We must cooperate fully in the development process. "Simultaneous engineering" and "partnership" make sense. In the development of new products, we must simultaneously take quality, speed and profitability into consideration. The designer, manufacturer and user must collaborate closely and turn a buyer-seller relationship into a partnership, starting from product analysis by the user, through designing, manufacturing and testing, all the way down to operation and maintenance.

3.2.5 It is recommended that we combine technology imports with independent development and make sure that development is the priority. Repeated importing of low-level products should be avoided. Domestic development should be encouraged to stimulate our own industry. Development of key CNC equipment should be encouraged and subsidized. Duties on necessary imports should be reduced or waived. Extended tax breaks should be given to new CNC products listed at the provincial, city and national level. A part of the profit generated should be given to organizations or individuals responsible as a reward.

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Optical Symbolic Substitution Based Truth-Table Look-Up Method Proposed, Digital Full Adder Designed

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[Article by Chen Lixue [7115 2980 1311], Yuan Shifu [5913 4258 1133], Lu Qichang [0712 0366 2490], Sun Fangkui [1327 5364 7608] and Wang Yong [3769 0516] of the Department of Applied Physics, Harbin Institute of Technology, Harbin 150006: "Truth-Table Look-Up Based Optical Symbolic Substitution"; MS received 17 Dec 90, revised 26 Apr 91]

[Text]

Abstract

A new optical symbolic substitution method is presented. By using complementary encoding and location-addressable memory, a full-adder digital processor with feedback computation capability is constructed. This symbolic substitution system is experimentally verified using a row logic device made of a liquid crystal light valve (LCLV) and the experimental results are also given.

Key Words: optical computing, truth-table look-up, symbolic substitution.

I. Introduction

In recent years, a number of effective optical computing systems and structures have been reported. Truth-table look-up,[1-3] optical symbolic substitution,[4-6] optical neural network[7] and carry look-ahead[8] are a few promising optical computing systems. In references [1-3], addressable truth-table look-up was implemented by means of an optical hologram. The final output is in the form of an optoelectronic signal and is not consistent with the input encoding scheme, which makes feedback computing impossible. In conventional symbolic substitution systems, parallel displacement of the pattern followed by superpositioning with the original pattern is required before implementing any logic operation. This makes the system structure overly cumbersome. In order to fully utilize the advantages of truth-table look-up and symbolic substitution, and to overcome their individual shortcomings at the same time, these two methods are combined in this work to create an optical symbolic substitution based truth-table look-up system. A top-digit [i.e., most-significant-bit] full adder with feedback operation capability is constructed based on this system. An LCLV row logic device is used to experimentally demonstrate this system.

II. Principle

Figure 1 is a block diagram of the structure of the optical symbolic substitution based truth-table look-up system. It consists of five components: input data plane, recognition truth-table mask, row-NOR logic plane, substitution truth-table mask and column-OR logic plane.

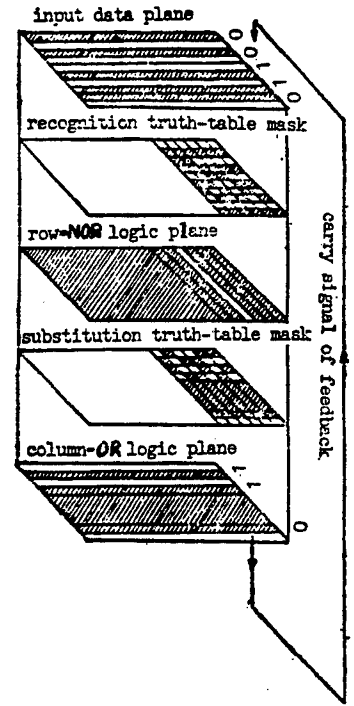


Figure 1. Block Diagram of the System

The system employs a light intensity complementary encoding scheme to create the digital pattern.[3] The input table look-up pattern and output encoding scheme are shown in Figure 2(a). Left white right black is 1 and left black right white is 0. The encoding of the recognition truth table is shown in Figure 2(b), which is complementary to that shown in Figure 2(a); i.e., left white right black is 0 and left black right white is 1. When the table look-up pattern and recognition truth-table pattern overlap, a number of possible situations may appear, as shown in Figure 2(c). A completely dark output is obtained only when the table look-up pattern matches with the recognition truth-table pattern.

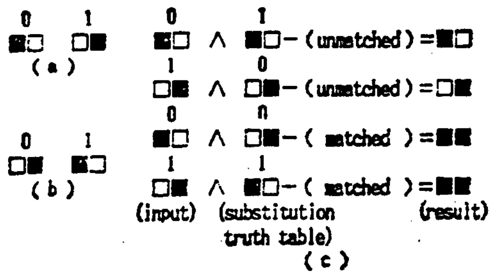


Figure 2. Encoding Method of One Bit of Patterns and Matched Results

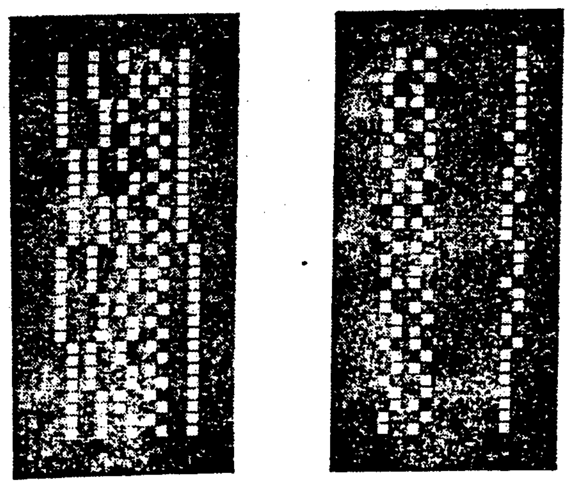
Key: (a) Input, output pattern and substitution truth-table pattern; (b) Recognition truth-table pattern; (c) Unmatched and matched results of input pattern and recognition truth-table pattern

The encoding of the table look-up input plane is derived from the method shown in Figure 2(a). Immediately next to the table look-up input plane is the recognition truth-table mask, as shown in Figure 3, which includes all the recognition truth modes corresponding to any possible input mode. Therefore, any single table look-up input mode will match with a unique truth-table mode to turn all elements in this row dark. Behind the recognition truth-table mask is a row-NOR logic plane. The unique feature of this logic plane is that as long as there is a bright input spot the output of the entire row is dark. Only when there are no bright input spots is the output of the entire row bright. Hence, behind these three layers, a row is bright only when there is a complete match between input and recognition. Other rows are all dark. This is the way input recognition is accomplished. The row of light shines on the substitution truth-table mask to obtain the corresponding input mode to complete the entire process. In order to keep the encoding of the input mode consistent to that of the output mode, the substituted mode is shined on the column-OR plane shown in Figure 1. The function of this logic device is to provide a column of bright output when there is one bright input element in that column. By using these five planes, an input mode can be recognized and substituted into a coded spatial light-intensity output which is consistent with the input mode in real time in order to implement location-addressable truth-table look-up symbolic substitution.

III. Implementation of Addition By Symbolic Substitution Based Truth-Table Look-Up Method

Since the optical symbolic substitution system described above is based on a truth-table look-up method, in principle, it is suited to the implementation of any operation. Furthermore, the degree of difficulty is the same for any complicated operation. The application of this symbolic substitution system is demonstrated by using addition as an example.

In order to construct an m-bit binary full adder, addressing is done by using a table look-up mode consisting of two m-bit binary numbers $A_{im}A_{im-1}...A_{i1}$ and



(a) (b)

Figure 3. Truth-Table Masks Used To Constructure Two-Bit Full Adder

Key: (a) Recognition truth-table mask; (b) Substitution truth-table mask

$B_{im}B_{im-1}...B_{i1}$ and a carry signal C_{i-1}. After recognition and substitution, this results in an output signal $S_{im}S_{im-1}...S_{i1}C_i$ which includes the sum signal $S_{im}S_{im-1}...S_{i1}$ and carry signal C_i. When dealing with the addition of numbers with most significant bits, such as the addition of two m x n numbers, we must consider linking the carry bits together. We can still use m-bit full adders and convert the addition of two m x n numbers into n full-adder operations involving m bits. Since the encoding of the input is consistent with that of the output, it is only necessary to return the carry signal of the m-bit full adder of the ith order to the input plane as the carry signal for the i+1th operation of the m-bit full adder. One by one, the m-bit full adder is used n times to complete the addition involving m x n-bit numbers.

Because of the use of a location-addressable truth table, the recognition truth-table mask and substitution truth-table mask should include all possible 2^{m+1} table look-up modes. The following is an example showing how full addition can be implemented with m = 2. Figures 5(a) and 5(b) are the recognition truth-table mask and substitution truth-table mask, respectively, including all $2^5 = 32$ modes. Every row in the recognition truth table corresponds to a row in the substitution truth table. By looking up the address from the input look-up table, the result of full addition corresponding to this input can be obtained.

IV. Experimental Set-Up and Results

In the symbolic substitution based truth-table look-up system, the optimal choice for the row-NOR and column-OR logic device includes two-dimensional high-speed optical switches and optically bistable arrays. Such devices, however, are not yet developed for practical use.

Row-NOR and row-OR logic devices have been constructed based on the non-linear threshold effect associated with the input-output characteristics of a liquid crystal light valve (LCLV). Satisfactory experimental results were obtained,[9] which demonstrates that these devices can be used to illustrate optical symbolic substitution by means of truth-table look-up. Figure 4 shows the experimental optical path used; it was built with these two devices. In the figure, LCLV represents the liquid crystal light valve, CL represents a cylindrical lens, BS is a beam splitter, D is a rectangular diaphragm, P is a polarizer, A is an analyzer, and M is a reflective mirror. The focal length of all four cylindrical lenses is f. MASK1 immediately behind the input plane is the recognition truth-table mask. The write-in distance between CL1 and LCLV1 and the read-out distance between CL2 and LCLV1 are both f. Together with BS1, D1, P1 and A1, they form the row-NOR logic device. MASK2 behind the mirror M is the substitution truth-table mask. The write-in distance between CL3 and LCLV2 and the read-out distance between CL4 and LCLV2 are also both f. Together with BS2, D2, P2 and A2, they form the column-OR logic device.

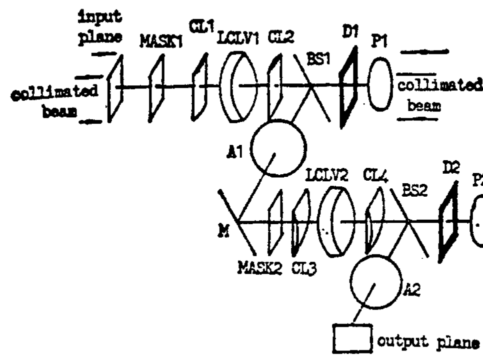


Figure 4. Optical Arrangement for Implementing Truth-Table Look-Up Symbolic Substitution

Since this is an experiment to demonstrate the principle and the truth table is location-addressable, one does not require a large truth table to prove the point. When adding two 2-bit binary numbers, after the table look-up input reaches the recognition truth-table mask, if there is a complete match for a specific row in the recognition truth-table mask, the entire row is dark. When there is a total mismatch, the row contains five bright spots. Hence, there are a total of six conditions for a row to show any bright spots: 0 (all dark) to 5. In this experiment, we used a recognition truth-table mask such as that shown in Figure 5(a), which consists of six modes, i.e., 00000, 00010, 01010, 10101, 10111, and 11111, and a substitution truth table such as that shown in Figure 5(b), which consists of output results 000, 010, 100, 011, 101, and 111 corresponding to the six recognition modes. Figure 5(c) shows the encoding method for the table look-up input of 01010. Figure 5(d) is the ideal output 100 for the table look-up input of 01010. Figure 5(e) shows the picture obtained experimentally. It was found that the symbolic substitution process could even be satisfactorily accomplished with the LCLV. With high-speed optically bistable switching devices, the system is definitely feasible.

V. Results and Discussion

The following conclusions can be reached based on the above discussion: Optical symbolic substitution can be accomplished by using a complementary encoded location-addressable memory based truth-table look-up scheme. Two-dimensional high-speed optical switches and optically bistable arrays are the most desirable devices for such a system. However, under the present circumstances, row logic devices can be constructed with LCLVs. Such a system was constructed to demonstrate the basic symbolic substitution process.

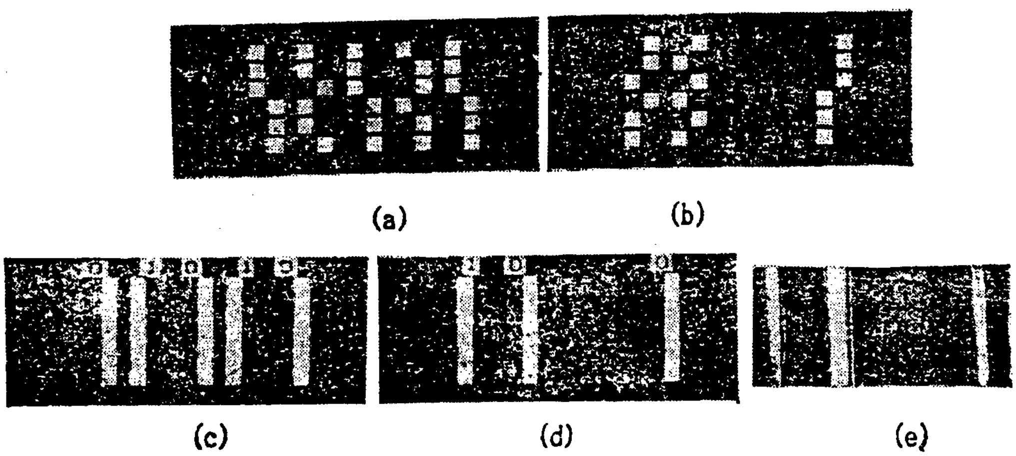


Figure 5. Truth Table for Experiment and Experimental Result

Key: (a) Recognition truth table; (b) Substitution truth table; (c) Input pattern for look-up truth table; (d) Expected result; (e) Experimental result

In this optical digital processing system presented, truth-table look-up is combined with symbolic substitution. As far as truth-table look-up is concerned, the addressable holographic truth-table look-up described in references [1-3] has a serious problem. The output encoding is not consistent with the input, which makes closed-loop feedback operation impossible. Even with a very large optical memory, it is impossible to meet the requirement for processing large-bit numbers. As far as symbolic substitution is concerned, conventionally the process involves mode recognition and substitution, which requires pattern movement. In this system, an addressable truth table is used for pattern recognition and followed by substitution of the corresponding mode. The entire process does not rely on any pattern movement. Instead, it depends upon a truth-table mask and some special logic devices to complete the recognition and substitution process. Furthermore, the input encoding is consistent with the output encoding, which can be conveniently used in feedback operation. Since there is one-to-one correspondence between the recognition truth table and substitution truth table, the system, in principle, is suitable for multiplication and other complex operations. However, because of the use of light-intensity complementary encoding, requirements such as mask memory storage density and LCLV resolution become too demanding. The switching speed of an LCLV is not very fast, which seriously affects the speed of recognition and substitution. Furthermore, the speed of the system is entirely determined by the response of the logic devices. If high-speed optical switches and optically bistable devices are used, the system will operate at an extremely high speed. Moreover, if a two-dimensional planar array of optical switches and bistable devices is used, the system can be constructed in a tightly laminated form. This can drastically save space and is a step toward integration. The authors have designed an improved LCLV to execute logic operations.[10] This symbolic substitution based truth-table look-up system is a very promising digital processing system.

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Plan Aims To Boost Satellite Telecoms

40100047A Beijing CHINA DAILY in English 16 May 92 p 1

[Article by staff reporter Xie Liangjun]

[Text] In a major step to expand satellite telecommunications across the country, China is building more earth stations in a dozen major cities, according to government sources.

Encouraged by the rapid growth of the postal and telecommunications industries, an ambitious programme was launched this year to develop the country's satellite telecommunications network.

Hao Weimin, chief engineer of the Directorate General of Telecommunications under the Ministry of Posts and Telecommunications, said yesterday in Beijing that China is constructing new ground satellite stations for domestic uses in Shanghai, Haikou, Shenyang, Harbin, Xiamen, Xi'an, Chongqing, Fuzhou, Lanzhou, Nanning, Kunming and Wuhan. The projects will be completed before 1995.

It will bring China's number of satellite-station-accessed cities to 19.

At present, ground satellite stations have been set up in seven cities—Beijing, Guangzhou, Urumqi, Lhasa, Huhhot, Chengdu and Qingdao.

Hao said in an exclusive interview on the eve of World Telecommunications Day, set for May 17 by the International Telecommunications Union with "telecommunications and space—new horizons" as its theme, that 23 ground satellite stations and three mobile truck-carried ones are in service around the country.

Hao said that China is erecting a VSAT-based voice network in Tibet, which will allow Tibetans to enjoy easy telephone connections with the outside areas when completed in the next one or two years. VSAT stands for Very Small Aerial Terminal, a newly-developed advanced satellite telecom technology.

Through ground satellite stations in Beijing, Shanghai and Guangzhou, 443 cities and counties, including all Chinese provincial or autonomous regional capitals, have combined with 196 countries and regions international direct dialling (IDD) telephone links and telegram services, middle-speed digital telecommunications, Intelsat business service, video-conference telephone or TV programme exchanges.

According to Hao, current home satellite telecom lines have made automatic direct dialling of long-distance telephone calls available among about 520 Chinese cities.

Satellite telecommunications has also brought coverage of television and radio broadcasting to over 80 per cent of the Chinese populace. He said that satellite telecommunications have played an important role in maintaining ties among remote border regions and other parts of China as well as developing and nurturing the economic and cultural lives of minority-populated areas.

China's satellite telecommunications sector kicked off in 1971 when the country used satellites of the International Telecommunications Satellite Organization (Intelsat) for its international service, and the sector has blossomed since 1984, when China launched its first experimental stationary telecommunications satellite into orbit. Since that year, China has successfully sent another five telecom satellites into space.

New Information Discovered on 'Tau' Particle Mass

40100046A Beijing XINHUA Domestic Service in Chinese 1124 GMT 23 Apr 92

[Report by XINHUA reporter Chen Jinwu [7115 6855 2976]]

[Text] The recent successful attempt by Chinese scientists to discover the mass of the "tau" particle is a major achievement in China's high-energy physics community. In order to get a better understanding of the significance of this achievement in the area of high-energy physics research, this reporter interviewed Zheng Zhipeng, deputy director of the Institute of High-Energy Physics of the Chinese Academy of Sciences and a researcher in the field of experimental physics.

Zheng Zhipeng said: The "tau" particle is an important subatomic particle discovered in 1975. Just like the discovery of the electron, proton, and neutron, its discovery is an important event in international high-energy physics circles. The study of particles is an important window on the world of microstructural physics. As scientific study advances, physical structures become better known. Nevertheless, it has become increasingly difficult for scientists to gain a deeper understanding of them. So far, the smallest physical units known to scientists are the quark, lepton, and intermediate boson.

Zheng Zhipeng added: Up until now, a total of six leptons have been discovered, one of which was an electron. The "tau" particle is a third-generation lepton. The study of basic physical structure not only requires an understanding of basic units—for instance, a search for new particles that constitute matter—but it also necessitates an understanding of the interaction and relationships between these particles in order that we can learn the rules that govern their physical interaction. So far, scientists have a great understanding of the characteristics of many particles, but their knowledge concerning the "tau" particle is quite limited. For example, the measurement of "tau" particle mass is still not accurate and little is known about its decay. If we are not clear about these questions, we will not be able to accurately describe the characteristics of the "tau" particle and the rules that govern its physical interactions.

Therefore, the accurate measurement of "tau" particle mass has become a focal point in international high-energy physics research in recent years. Zheng Zhipeng said: There are at least two reasons that can explain why scientists are so concerned about the mass of the "tau" particle. First, it is very difficult to measure "tau" particle mass. The "tau" particle can be produced only by relatively high energy. "Tau" particles, which are produced in small quantities for extremely short periods of time, can only be calculated by their decay daughters. The fact that relatively large margins of error have resulted during attempts to measure "tau" particle mass—measurements that have been conducted only four times in history—proves the difficulty of these attempts. In addition, the "tau" particle's mass is related to the so-called universality of the lepton's weak interaction in the field of high-energy physics. The result of our research has indicated one thing: that the new information on the "tau" particle mass has further raised the question of whether the weak force is universal in the standard model.

Zheng Zhipeng said: When compared with international high-energy physics research, our research has had a late start. But the speed of our development is very fast. The Beijing-based electron-positron collider, which successfully conducted its collision experiment in October 1988, is mainly used to conduct research in charmed particle physics and lepton physics. During the course of our research, we have gradually gained specialities of our own and achieved universally-acknowledged results in a relatively short period of time. The Beijing-based electron-positron collider, which can produce stable energy with relatively high brightness and strong particle-discriminating capabilities, provides a technical guarantee for more results of important high-energy physics experiments in the future.